AN INTRODUCTION
TO
GEOLOGY AND MAGNETISM.

By EVAN HOPKINS, C.E. & F.G.S.

AN

ILLUSTRATED INTRODUCTION

TO THE CONNEXION OF

GEOLOGY AND MAGNETISM;

OR THE

PRINCIPLES OF TERRESTRIAL PHYSICS.

BY

EVAN HOPKINS, C.E., F.G.S.

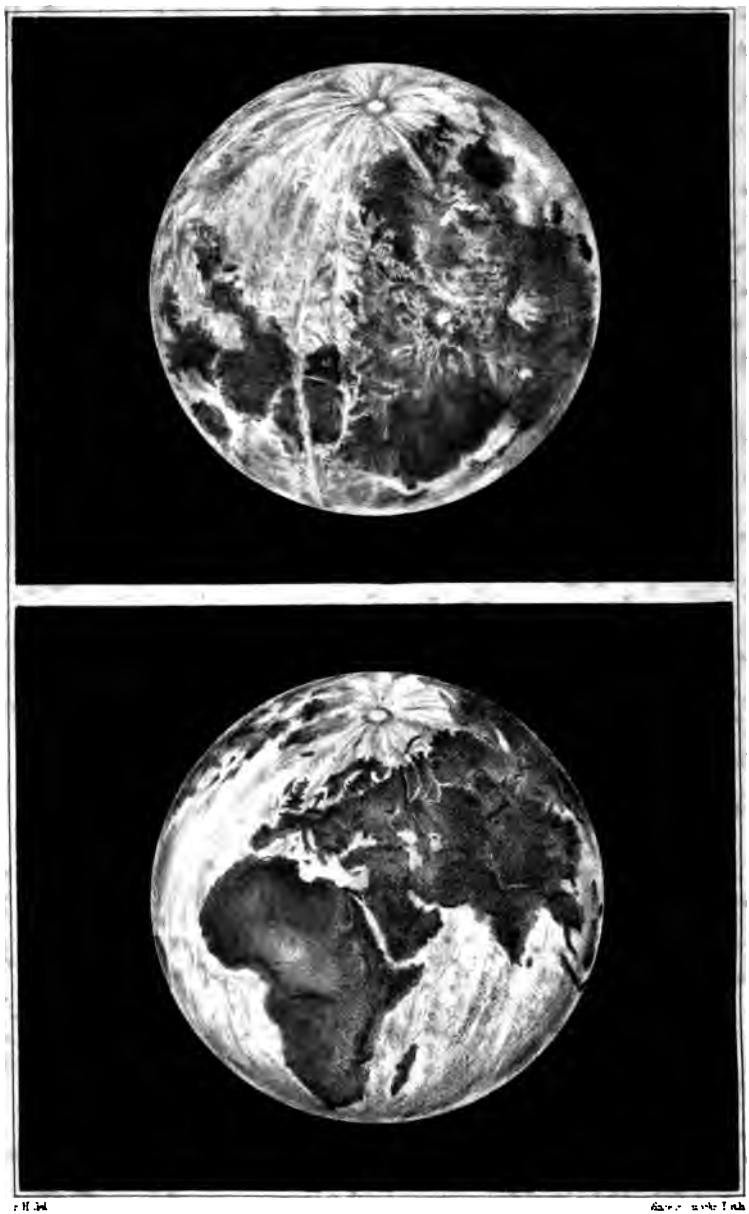
WITH A GEOLOGICAL SECTION ACROSS THE ANDES.

*** The Third Edition of the enlarged work, including the new Illustrated Introduction, with an Appendix "On the Gold-bearing Rocks of the World," &c., is now published.


BIBLIOTHECA · BODLEIANA ·

THE MOON, AS SEEN FROM THE SOUTHERN HEMISPHERE.

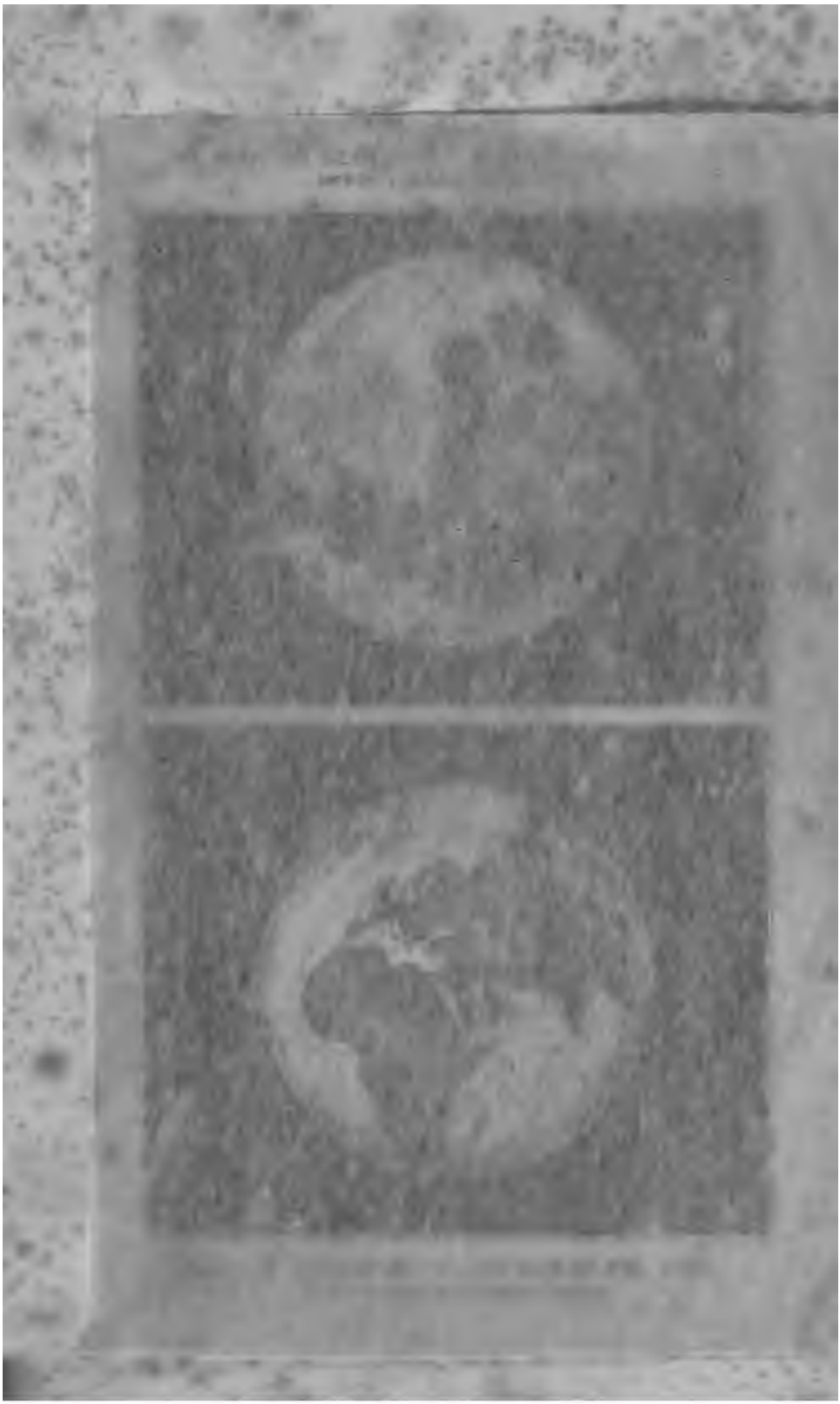
SHEWING HER VISIBLE NORTH POLE.



THE EARTH, REDUCED TO THE SIZE OF THE MOON,

WITH ITS NORTH POLE TOWARDS THE SUN.

ON THE CONNEXION OF



ON THE CONNEXION OF

GEOLOGY

WITH

TERRESTRIAL MAGNETISM:

SHOWING

THE GENERAL POLARITY OF MATTER,
THE MERIDIONAL STRUCTURE OF THE CRYSTALLINE ROCKS,
THEIR TRANSITIONS, MOVEMENTS AND DISLOCATIONS,

INCLUDING THE

SEDIMENTARY ROCKS:—THE LAWS REGULATING THE DISTRIBUTION AND CONCENTRATION OF METALLIFEROUS FORMATIONS,

AND ALL OTHER OPERATIONS CONNECTED WITH TERRESTRIAL PHYSICS.

BY

EVAN HOPKINS, C.E., F.G.S.

The minerals and the rocks, the rivers and the seas, the islands and the continents, with their vegetable and animal covering, are perpetually changing. There is no standing still, and no resting-place in the annals of the world. Generation after generation, like the shadow on the dial, pass away and all are continually merging into eternity.

THIRD EDITION,

WITH NEW INTRODUCTION AND APPENDIX, THIRTY-ONE PLATES, AND NUMEROUS WOODCUTS.

LONDON:
TAYLOR AND FRANCIS, RED LION COURT, FLEET STREET.
1855.

"Few things can, perhaps, do more to raise and expand the general mind than a knowledge of the laws which are observed to be fulfilled in the operations of nature around us; and any one who should increase the facilities for acquiring such knowledge would confer a considerable benefit upon society. Any one who writes a work setting forth more clearly and correctly these laws, so that they can be thus brought within the reach of a larger number than hitherto, deserves our thanks."—*Mechanics' Magazine.*

"We freely confess that we are entirely unacquainted with the laws of terrestrial magnetism; and if any philosopher be so fortunate as to bring these laws to one principle, it will no doubt be one of the greatest discoveries ever made."—*Biot.*

PREFACE.

THE First Edition of this Work was written in South America, during the years 1837 and 1838, printed in a volume in 1843, and has been since in the hands of Mining Engineers and others in all parts of the world. It is very gratifying to find, not only that many of the most intelligent practical men of all countries have approved and applied the principles enunciated therein, for their guidance in metalliferous deposits, but also that the principles of the 'Connexion of Geology with Terrestrial Magnetism,' have been received and acknowledged, by numerous scientific men of all nations, as the most consistent with the actual conditions of the rocks of any yet propounded. The slow operations of that power we call terrestrial magnetism, if only attended to, account, in the most striking manner, for all the changes observed on the surface of the earth, in the structure, combinations, sequence of the crystalline and sedimentary rocks, individually and collectively.

This theory has not been merely assumed to account for any given phænomena of changes going on, but is the natural and legitimate resultant of innumerable classified laws, when combined into one system of operations.

Soon after the publication of the First Edition, I had the advantage of resurveying a large portion of the Andes, from the Equator to the Caribbean Sea, also across from the shores of the Pacific to the sources of the Orinoco, Amazon, &c. on the east flank of the eastern branch of the Cordilleras. Subsequently I made a general survey of the Isthmus of the Darien to Veraguas for the Government of New Granada; I also inspected and made a survey of some of the islands in the Pacific Ocean and the West Indies.

Since the issue of the Second Edition, I have travelled over a very large portion of the Eastern Hemisphere, from Europe to Australia, *viâ* the Indian and Chinese Archipelago to the southern coast of Australia, and carefully examined the geology of a large tract of land, islands, &c., and made many scientific observations connected with terrestrial physics.

In comparing the primary structure, metalliferous deposits, and sedimentary beds, with those previously investigated in the Western Hemisphere, I have had the great and inestimable satisfaction of finding strict coincidence in the respective zones, thus fully confirming the views I had laid down in my First Edition.

The new Introduction and appended notes, with the additional illustrations, will, I hope, render this Edition more explanatory, and still more worthy of the attention of practical men of science than the last, and be found to contain stronger proofs of the soundness of the principles brought forward: besides, the innumerable corroborative facts which are daily coming to light, show that this system is

well-founded, and that it must progress and outlive all opposition.

It cannot be expected that any new system of terrestrial physics, that tends to upset all our preconceived notions, should be permitted to be announced, much less accepted, by an enlightened scientific nation, however self-evident and consonant it may be with the natural laws of the Universe, without the strongest opposition and the most severe investigation. A system that is unable to undergo the strictest scrutiny in all its corollaries, and not possessing sufficient inherent power to conquer all opposition and surmount all obstacles, without the aid of artificial support, is undeserving of notice. Natural truths, or physical facts, must always prevail in the end, no matter by what amount of resistance they may be opposed.

The age in which we live is the age of progress; it is the age of utilitarianism,—the useful applications of the new and available discoveries, which are daily being made in the sciences of Magnetism, Electricity, Chemistry, Galvanism, Engineering, Geology and Mining, overcome all the prejudices of antiquated ideas. It matters not how lofty and grand our old theories might have appeared to us formerly, in their physical generalizations; if they cannot be applied to the uses and acquirements of the present age, they stand on perishable bases, and must ultimately give way to those which are found more in accordance with the facts emanating from our scientific progress.

When the prevailing theories were first established, so little was known of magnetism, electricity and geology,

that these sciences were scarcely noticed. Indeed Prof. Leslie, not many years ago, ridiculed the idea of magnetic currents, and fluids, as well as many other physical facts which have subsequently become almost indispensable to household science. The tidal waves are totally different to the theories of mathematicians; and mariners are obliged to be guided entirely by local and daily observations.

Mathematicians have actually attempted to support the assumption of an igneous globe enclosed in a thin semi-aqueous shell, solely by the aid of mathematical reasoning, in order to account for the apparent irregularity and the chemical actions which we see on the surface of the globe.

Observations and experiments must necessarily form the very foundation of true philosophy; but owing to the great labour, time and difficulty attending the acquirement of those essential elements for investigation, men have established dogmas for causes, trusting opinions as data, and building hypotheses on unsound foundations.

Mathematical studies are of great value in the minute investigation of any branch of physics; but they are not indispensable to an accurate knowledge of principles, as proved by the results of the labours of many of our experimental philosophers, who have done so much for the progress of science by their valuable researches and discoveries. The present age, unlike the past, does not take everything for granted from professors. Matter of fact is superseding the era of the marvellous and assumptions; all objects within the reach of man must now be brought

to an *experimentum crucis* before they are accepted or appreciated. We are not to be attracted by mere learned erudition or prolix propositions; we must have plain reasons or experiments, before we admit that hypotheses and dogmas have greater weight than the facts observed by our explorers. To depend on mathematics alone, is an abuse of its uses—mere lines and circles, shadows without substances,—as without observations or experimental data, little can be done in any inquiry connected with the physical sciences.

Hypotheses are often assumed and pertinaciously supported by the most refined analysis, against the evidence of reason; and if we did not know that pure mathematics is capable of constructing a theory on any physical data, *pro* and *con*, and as a consequence that many things which have been pronounced mathematically certain, have been often proved experimentally wrong, we should have felt reluctant to question physical theories founded on the laws of geometry.

In perusing the following pages, it will be observed that the facts which I have brought forward have been accumulating for many years, in different regions of the globe, and by linking them together into one consistent whole, they form, as a consequence, a general law to guide us in terrestrial physics. It is therefore far preferable to extend the application of well-known principles, by uniting them together, in order to account for all terrestrial phænomena, than to invent or assume theories and conditions which are irreconcileable with the existing laws.

I have no other object in view in publishing this work, than that of communicating the result of my researches, for our general guidance in scientific and useful practical pursuits; and to endeavour to remove some of the theories which are untenable and injurious to the progress of scientific truths. I feel that I have been fully rewarded by the pleasure I have enjoyed in distant regions during the development of these new truths; observing the gigantic operations of Nature in countries so little known to the scientific men of Europe.

Indeed I rejoice in having had the privilege of travelling over so great a portion of the world, with the advantage of possessing and employing the best scientific instruments, and in having been able to observe, study, and note down, the world as it is, and not as it has been made in the closet. Even if I stood alone, and were opposed by all others in this new system, I consider it a sufficient recompense to have been able to follow the connexion of all the physical operations of nature to one primary cause, and to have had the inexpressible pleasure of observing the sublime harmony of the works of the Creation in so many parts of the world.

I have found that the past was in accordance with the present order of things—all subject to the changes and renovations of that great controlling power, which we call polarity—thus impressing upon us the uniformity and unchangeable character of nature's laws, and making us look up with solemn admiration to nature's Author.

In leaving this interesting subject to the reflection of

the attentive reader, I do so with a mind fully conscious of human imperfections and errors in matters of detail, which must necessarily occur in the treatment of so large a subject unaided, and investigated solely by myself; yet I feel strong in the conviction of the truth of the *general principles*, inasmuch as they have been fully borne out, not only by my own observations, but also corroborated by various experiments and the observations of many others.

Indeed it would appear presumptuous on my part to question the opinions and doctrines which are regarded as founded on the unerring laws of mathematics in connexion with those of physics, had it not been for the fact, that we find the world differently constituted to what it has been represented; and as mathematical theories necessarily depend on the data, and are capable of being modified in accordance with assumed conditions, the sooner the real state of the globe is known the better.

The reader, before perusing the following pages, should endeavour to renounce and free his mind from all preconceived ideas, and keep it in a waiting attitude ready to receive the evidences of the various phænomena, however opposed they may be to established doctrines.

Our isolated surveys have accumulated to a vast amount, but for want of "connexion" they lose a great part of their interest. Important new facts are increasing in all parts of the earth, but for the want of a key to open and disclose their united meaning they lose their value.

If we obtain a clue to the grand cause, the mind returns to the dark and barren waste over which it has been

hovering in doubt and perplexity; and by the guidance of this simple torch, it embraces, under the comprehensive grasp of a general principle, the multitudinous and insulated phænomena which had heretofore found neither value nor "connexion." It is not the collector of shells and flowers, of fossils and crystals, that can give an account of the general character of a country, and speculate on the problematical causes of its conditions, but the man who has traced its great outlines, the connexion of its parts, and from an eminence surveyed its leading features. The same with the globe; we may waste centuries of valuable time and labour in accumulating things of comparatively little value, building and destroying in succession hypothetical superstructures, and allowing questions of greater magnitude and importance to pass by unnoticed.

I beg to impress on the reader's mind, that the principle herein enunciated is not a human invention, nor concocted with any interested motive, but is only communicated to show its great value and importance for the guidance of the human race. I have only been the humble instrument, who has had the pleasure of watching for many years its sublime operations, and I have endeavoured to interpret its laws in such a manner as to be comprehended and appreciated by all; in the hope that it will lead to important results, assist us in our progress,—and direct us to the right way to develope the great productions of nature for the benefit of mankind.

EVAN HOPKINS.

38 Thurloe Square, Brompton,
London, August 7, 1855.

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OPINIONS OF THE PRESS.

"THE book contains very valuable information, somewhat closely connected with topics of great interest to this country..... It is quite beyond my ability to give a fair analysis of this book; and I will conclude what I have to say by recommending those who are practically acquainted with the mineral condition of the country to peruse the chapter relating to the filling of veins. It seems to me to throw out lights which might or might not fall in with their local experience; but which would at all events afford matter for profitable inquiry and comparisons," &c.—*Sir Charles Lemon, Bart., M.P., President of the Royal Geological Society of Cornwall, in his Annual Address*, 1844.

"In this case, nature accomplishes on a large scale what experimentalists achieve with the galvanic battery; and if we admit the existence of subterranean currents, and that these exert a slow decomposing power, like that of the battery, we have sufficient power for our purpose ..... In this way may be explained the formation of veins that have long puzzled the geologist. This places geology and magnetism in quite a new light, disclosing a field of labour that promises a brilliant harvest to the persevering investigator," &c.—*Chambers' Journal.*

"Hitherto geological science has been designated as a vague and useless doctrine by many of our practical miners; and it is true, that primary rocks, with their mineral veins, have been left by speculative geologists, as *terra incognita*, in complete obscurity; but we are happy to observe a change for the better; the science is beginning now to have a more useful and practical bearing, and men are getting more anxious to learn it; and it is to be hoped, that with this combined influence and the diligent accumulations of new facts, such a degree of certainty will be obtained, as may enable them to predicate with some confidence, not only questions connected with mineral deposits, but likewise all phænomena which it comprehends. We have been led to make these observations on this interesting subject, in consequence of Mr. Hopkins's new system of Geology, which, owing to its practical applications to mining, and the satisfactory manner in which it accounts for all phænomena connected with terrestrial physics, is becoming an established system with practical men. The interest has been considerably enhanced of late, owing to the recent discoveries made by the indefatigable Dr. Faraday, corroborating, in a remarkable degree, Mr. Hopkins's general views, as explained in his work."—*Mining Journal.*

"The igneous theory—the doctrine of central fire—has for some time been

slowly yielding to other views. All the phænomena attributed to fire may be produced (according to Mr. Hopkins's system) by electro-magnetic currents. It is difficult to imagine the existence of fires unsupplied with the oxygen of the atmosphere . . . . . Even the cause of the variation of the needle, mysterious as it has hitherto appeared to be, may be referred to the relative energies of the magnetic currents. The wasting away and degradation of the land, which have often been viewed with alarm, are now shown to be compensated for by a process tending to the renewal and perpetuation of the physical universe. We look forward to the labours of Professor Faraday, as destined to throw further light on this interesting branch of science, in which he has already done so much. According to Sir John Herschel, we are to look to electro-dynamics for the *vera causa* of the Newtonian philosophy."—*Chambers' Journal, August* 1847.

"It is the best, and indeed the only principle hitherto propounded, which is capable of accounting for the various and complicated phænomena of geology, in a clear and satisfactory manner, in this, as well as in all other parts of the world, with which I am acquainted."—*Extract from a letter received from a geologist in Peru.*

"It is an acknowledged fact by all miners that the geology commonly taught is of no avail to them, and even the character of the primary rocks and the mineral veins is so imperfectly described, as to mislead those who study them from the ordinary books and lectures on geology. It is admitted also, that the only practical system of geology applied to mining, and now used by mining engineers, is 'Hopkins's Geology and Magnetism.'"—*Mining Gazette.*

SECOND EDITION.

"We strongly recommend a complete study of this work from beginning to end, so that not only the connexion of all its parts may be clearly understood, but to bring conviction to the mind of its demonstrative truths."—*Atlas.*

"Totally at variance with all the absurd dogmas of the igneous theory . . . presenting a true philosophical principle of terrestrial operations in every part of the world. How admirable are its explanations in metalliferous deposits and the gold fields of these colonies!"—*Colonial Press.*

"This is the most extraordinary work on record, and is truly the only work hitherto published on Geology which gives us a rational explanation of the changes we see going on in this world . . . . . *Geology and Magnetism* will be appreciated, when many other works, now held in high repute, will be forgotten . . . . . It is a lasting monument of high acquirements, and must command the respect and attention of every one who is capable of appreciating its value, and feel an interest in the laws of terrestrial physics."—*American Paper.*

INTRODUCTION.

It will be admitted by all philosophers, who are labouring more for the cause of truth than for that of upholding human doctrines, that the conclusions of Geology, like those of every other inductive science, should be grounded on the *sole* authority of well-ascertained and classified facts, properly established; and that we should be guided to such facts, neither by random conjectures, nor by the dictation of authoritative opinions, but by the *sole* pursuit of natural analogies, and unquestionable data founded on direct observations in all parts of the world.

Were we to proceed on such philosophical principles, we should soon see that the science of geology is not such a crude, incongruous, confused compound of elements, as many now suppose it to be. On the contrary, we should find it most beautiful and harmonious in its design, order and arrangement, wonderful in its productive results, and, in a word, most sublime in the general œconomy of nature. It is man—owing to the short period of his existence—his very circumscribed sphere of action, the fertility of his imagination, and his not being able to place himself at a distance whence he could view the whole operations of nature and comprehend the grand scheme of the creation—who describes this globe of ours as an accidental and artificial product—hot or cold, hollow or solid—a wreck of worlds,

or a chaos of melted matter, according to the immediate object of his thoughts and inquiries.

Violent incandescent eruptions are often assumed to account for physical changes, which may be observed as daily taking place in different parts of the world, by means of the ordinary slow and imperceptible process of nature. Our globe, according to the notions of many persons, has been brought to its present state of mineral structure and configuration, by repeated melting, roasting, boiling, freezing and scratching, as fancy or fashion may lead the way. These theories, however, do not, generally speaking, proceed from men who have been thoroughly trained in the laws of terrestrial physics and practical science, nor from persons who have examined and studied the phænomena of existing volcanoes, their effects, glacial movements, and the laws of metalliferous changes, as seen in various parts of the world; on the contrary, they often proceed from geological aspirants, who have never seen any other rocks than those in the immediate vicinity of their local habitations, which may not equal a spot that could be covered by the point of a finger on a globe of six feet in diameter, nor yet a depth equal to the thickness of its varnish coating.

Unfortunately it frequently happens, that the more limited the experience and scene of observation, the greater the presumption and consequent injury done to the progress of the science of Geology; we need not therefore be surprised at the extravagances and inconsistences of many of the theories advanced.

The science of Geology is comparatively of very recent date, and is pre-eminently one of direct observation, requiring careful and extensive analysis, mineralogically, chemically and mechanically, in connexion with natural

history. Besides, these examinations must not be confined to any given district or region, but should be extended over the entire surface of the globe before the question can be justly comprehended.

The want of these essential elements for the investigation, the tendency of the human mind to draw conclusions from isolated and exceptional phænomena, confined to limited districts, and the assumed fanciful hypotheses which are so often substituted for facts, are the causes of the difficulties attending the progress of the geological science, and of its being unavailable for useful purposes, and held in such low estimation amongst practical men. Let us turn over a new leaf, and read the book of Nature as we see it, neither adding to, nor taking from it the meaning of its true context; and let us endeavour to interpret each page as we progress, or in other words, let us act as if we were strangers coming from the realms of space to examine this globe, to make a systematic survey of its contents, movements and changes, and to give a faithful account of the whole, irrespective of the theories of its inhabitants. This is the only way to act if we intend to proceed in our labours in the true spirit of philosophy. We must revise our theory of terrestrial physics, to render it worthy of our esteem; and make it *equal* to the present advanced state of practical science and its branches as applied to human industry.

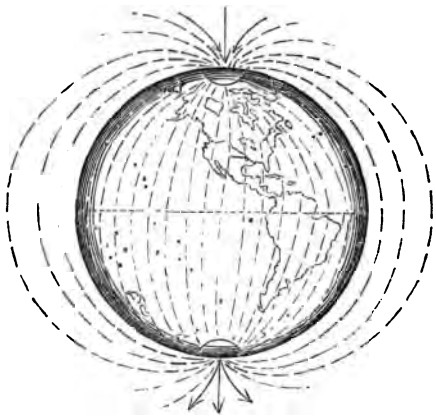
On entering into the subject of our inquiry, we must necessarily investigate the whole of the terrestrial sphere as we now find it—with its aërial, aqueous and semiaqueous covering, permeated with that universal power which we call polarity or magnetism. We must then watch carefully their combined operations—the changes and sequence which actually belong to them, and follow their natural consequences.

Let us endeavour to keep ourselves strictly within the boundary of demonstration, taking nothing for granted, but confining our investigations to the existing laws of operations, and to the accumulated mass of unequivocal evidence lying before us, without in any way altering their characteristic conditions and effects.

In taking a general view of our globe, we find that it

Western Hemisphere.

Fig. 1.



Eastern Hemisphere.

Fig. 2.

rotates on an axis, the two ends of which are called the South and North poles, and that it is not only enveloped

in an atmosphere, but also enclosed in an invisible and subtile power, which we find universally present, and which is incapable of being removed by human means. The existence of this power is ordinarily known by the indications of the magnetic needles, forming what are commonly called magnetic meridians, which converge at the respective poles, as described in figures 1 and 2.

All mariners who have traversed the ocean from the Antarctic to the Arctic regions, are necessarily familiar with the fact, that the south ends of the magnetic needles drop, and if suspended tend to become vertical, as they approximate to the South pole, and as they recede, the needles, with some slight local variations, are retained and preserved, more or less, in the meridian, until they approach the North pole, when the north ends begin to drop, and if suspended, will become vertical when in close proximity to the pole.

These facts are so well known as not to require further comment in these preliminary observations.

They have been further proved experimentally, showing that such is the linear direction and general character of the curves from pole to pole on a globe under the influence of that power called Magnetism. These meridional lines of active forces, traced from pole to pole, are not confined to the ocean, but are also detected all over the dry land, in the air above, in the waters below, and in the deepest recesses of the earth beneath; and this important fact is capable at all times of being put to the test in every part of the world, and therefore beyond the power of contradiction.

The next striking and general fact we detect is, the tendency of the crystals, that compose what we denominate

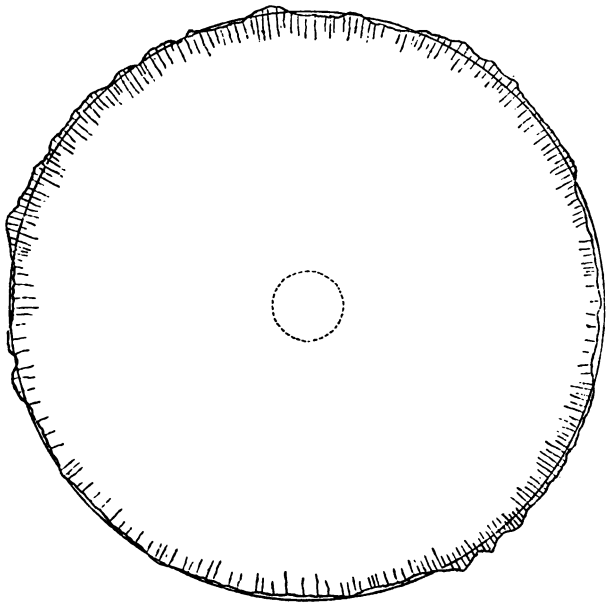
primary rocks, to form in a linear direction, and in compounds of crystalline plates, more or less, in a vertical position, with a similar meridional disposition as the magnetic needles, thus indicating a connecting cause. The diagrams annexed will, at a glance, show the general character of the structure of the primary rocks, as observed in all parts of the world, when carefully examined on a large scale, and in deep sections.

Fig. 3.

Fig. 3 exhibits the meridional structure of the primary rocks (granite, gneiss and schist) of the Western Hemisphere, from Terra del Fuego to the northern regions. Fig. 4 shows the same kind of structure from Van Diemen's Land, Australia, Africa, India, China to Siberia and Norway. Fig. 5 is an equatorial section, exhibiting the vertical or rather (with reference to the globe) the radial character of this meridional structure, called lamination, cleavage planes, foliation, &c., forming crystalline bands which are commonly mistaken by many geological writers for upraised sedimentary beds or tilted strata.

Fig. 4.

Fig. 5.



Locally, in districts where mica and talc happen to have aggregated in unusual proportions, as compared with the other ingredients, the schistose variety becomes often much contorted into various folds, undulating and causing an apparent want of conformity to the general order of the primary structure, and sometimes in ridges inclining from the perpendicular into a fan-shaped structure; but these deviations, when viewed on the large scale, are very insignificant, and are, comparatively speaking, not so much as the contortions produced by small knots and branches on the direction of the fibrous and medullary rays in the trunk of a large tree. The deviations of the polar structure of the primary rocks, when viewed as a whole, are not so much as the variations in the direction of the magnetic force indicated by the needles, and yet the latter appears remarkably uniform, when we consider the presence of so many disturbing causes, and is found quite sufficient to guide our track in the darkest night in the middle of the ocean. We find that the greatest discordance, both in the direction of the magnetic needles and in the polarity of the structure of the primary rocks, exists in the northern region. From the south to the north temperate region, the respective polar phænomena are remarkably uniform, as will be seen on reference to the above diagrams, and the following notes.

Australia.—The phænomenon of the polarity of the primary structure is so striking in this part of the world, that the most superficial observer cannot help noticing it.

Whenever the crystalline rocks, slates, &c. are found uncovered and exposed to view, they are found *on edge—bearing north and south*, and continuing in that direction to an indefinite extent, without any deviation for many

hundreds of miles, until hidden by layers of loam, sand and gravel.

In Mr. W. Howitt's recent work on Victoria, p. 71, vol. ii. he observes, "As I have said, these quartz ridges form portions of those singular ridges of rock which run from north to south over the hills of the gold regions here. A great portion of these ridges consists of clay-slate, or ferruginous sandstone, the strata (bands) being all perpendicular. It would seem as though some subterranean force, acting in this direction, had burst up the strata (crystalline bands) in these long north and south lines, and left them standing edgeways. They have a most singular appearance in the rocky woods, crossing the summits of the hills, and extending down the slopes, but disappearing in the valleys, being there buried by the alluvial soil. In the creeks, where the bare rock appears, you again perceive these ridges. They are always true to this one direction, and are nearly as good as a compass where they prevail; and you may trace them for twenty or thirty miles at a stretch, and, no doubt, they extend right across the Colony."

In the Proceedings of the Royal Society of Van Diemen's Land, vol. i. part 1, we find it stated that "Everywhere the bands of clay-slate are discovered in the same vertical position, and everywhere they have the same meridional direction..... Long Point is formed of massive granite, with clay-slate in vertical and meridional direction." In South Australia, "The mountain chains are composed principally of gneiss, mica-slate, chlorite-slate, and clay-slate enclosing quartz veins, and all on edge, running north and south, partially covered by sandstone and gravel." In the official reports on the Gold Regions of New South Wales, the same kind of polar structure is noticed:—"A

large range of granite runs north and south in various bands, with boulders loosely scattered on the surface, in the plains of Bathurst. Further westward, towards the gold-bearing rocks, the formation changes into a series of white quartz and mica-slate, to Summer Hill Creek; thence argillaceous, chloritic, and hornblendic slates, to Canobolas range—all without exception in a vertical and meridional direction, and these extend from north to south throughout the colony." To be brief, it might be stated that this vertical and meridional structure of the primary series has been traced from the Australian Alps on the east, across the Colony of Victoria, Mount Alexander, the Pyrenees, and the Grampians; thence to South Australia, to Swan River on the west coast in Western Australia, and as far inward as travellers have been able to penetrate into the sandy desert. On the northern coast the same structure is seen continuing from New South Wales to Cape York in Torres Strait, and also in various parts in the slaty portions of New Zealand. This meridional structure is seen intersecting Java, Sumatra, the islands of Banca, Borneo, and the Philippine Isles. It has been examined and partially traced from Singapore, along the Malay Peninsula as far north as Thibet, as a vertical meridional compound of granite, gneiss, quartz, micaceous and ferruginous slate*.

* "In the Malay Peninsula the bands of crystalline rocks are in general vertical, bearing sometimes to the west and at others to the east of north; but the average strike is about north and south magnetic. These bands of rocks run like walls amongst the trees and jungle, and may be seen in many parts of the coast in rows of ledges stretching into the sea, and thus forming numerous reefs, on which corals grow in profusion. Some of the vertical crystalline bands standing amidst the low trees and shrubs appear like the walls of ruins, some being only about a foot in thickness, while they rise to the height of 20 to 30 feet. Quartz bands are numerous. Many of the micaceous and

It has been carefully examined also in the island of Ceylon, and observed over a large area on the western side of Hindostan and in parts along the Himalaya Mountains. Sir Roderick Murchison, Baron Humboldt and others, have noticed the same kind of meridional structure along the chain of the Ural Mountains, and part of Siberia.

The meridional structure of the crystalline series prevails in South Africa, and in the interior as far as it has been explored in the south, and along the banks of the rivers on the west. We trace it also in Abyssinia, Nubia, and near Suez; on the north coast of Africa; in a word, wherever the primary series is left bare, and uncovered by the sedimentary deposits, the vertical structure is observed.

Europe is so much covered by sedimentary rocks as not to allow the primary rocks to be examined, except in very few places, and even many of these are found so much disturbed by subterranean forces, as not to present the same polar order of structure as in the regions above specified; hence the cause of the phænomenon not being understood or appreciated by European geologists. However, notwithstanding these obstacles, we find areas of moderate extent of uncovered primary rocks in Sweden and Norway, retaining with a little bend their normal meridional structure.

talcose slates often present on their worn surfaces a strong resemblance to decayed wood, and the small nodules of quartz look like knots. Indeed had it not been for the fact, that these rocks can be traced for some hundreds of miles north and south, they would be considered as fossil wood. This appearance arises from the fine lamination of the slates and the different colours, with the undulating seams of the mica, talc and chloride, giving all the appearance and varieties of grain which a large plank does. 'These bands vary in colour from chocolate to violet (but sometimes also bluish and greyish), the folia extremely fine, and a glistening lustre on their faces or cleavage planes. Wherever there is much quartz and talc the bands and laminæ are greatly deflected."—*Journal of the Indian Archipelago.*

Also (with a slight variation to the N.E.) the primary series may be traced from Ireland to the N.E. coast of Scotland. This structure is well developed in the Western Isles, where the gneiss and schist can be examined. A small range may be seen in Wicklow running north and south, and a few patches in Cornwall, Wales, and the slaty districts of the North of England, having a bearing to the N.E.*.

Portugal and Spain show the character of the structure of the gneiss, over a very extensive area; we find it also in France from the Gulf of Lyons to the English Channel; in Germany the same kind of structure may be seen in various places, more especially from Vienna to Berlin.

In *the Western Hemisphere* the meridional structure is first seen in Terra del Fuego, then throughout Chili, Patagonia, the Brazils and New Granada; also across the three branches of the Cordilleras, as shown in Plate VII.

The following sections from East to West will serve to give a general idea of many parts of the primary series of South and North America, transversely, partially covered by sedimentary rocks:—

Section from East to West.—Fig. 6.

Fig. 7.

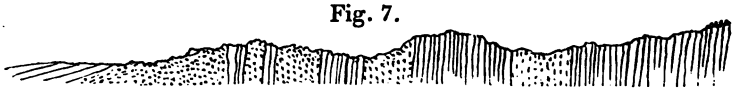


Fig. 8.

* As the slaty cleavage of the old sedimentary rocks has been induced by the primary structure underneath, it serves the purpose of tracing its direction, although covered by such deposits.

Fig. 9.

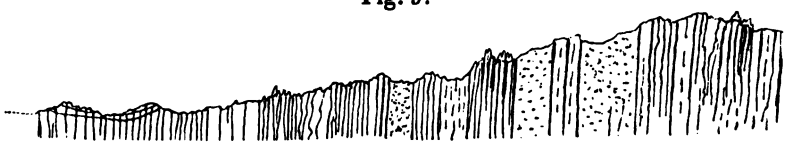


Fig. 10.

It would be an endless task to describe the various localities, as they all present the same character. In Veraguas and Central America, from Mexico to Sierra Nevada in California, the meridional and more or less vertical structure prevails, as will be seen on reference to the geological description of the respective countries.

To the East and bordering the Appalachian Chain, from the states of Georgia and Carolina, to Canada and Nova Scotia, although somewhat bent into a north-easterly direction like the crystalline rocks in Europe, the order of the primary structure is sufficiently uniform to display its prevailing character, and to show the magnitude and universality of the polar phænomenon.

Currents of the Ocean.

We shall next proceed to notice another general phænomenon which has some reference to the poles; it has been somewhat neglected by scientific men, although well known to mariners;—we refer to the great movements of the oceanic currents from south to north.

To those who have not been much on the ocean, and who are not accustomed to nautical language, the expressions of "going up" or "going down" in the middle of the sea would sound strange. For instance, captains on

the Atlantic and Pacific oceans say that they are "going up" to the Capes Hope and Horn,—Australia, &c., or "down" to New York, England, California, &c.; these sound something like arbitrary terms, yet they are strictly correct; they are expressions in accordance with the direction in which the currents of the ocean flow, viz. up against the stream and down with it. The general currents of the ocean are as familiar to mariners, as the Gulf-stream is to the Americans. Whatever drops on the ocean in the southern zone, if not checked in its course, and if preserved floating, will finally be carried to the northern regions.

The west coast of Ireland and the north polar regions present many examples of this great movement of the ocean. It is true we have no such meridional linear order in the saline liquid as that just described in the rocks and magnetic needles, yet the path of the streams may be traced along the configuration of the great continents and islands from the south to the north. These streams are propelled by impulses of periodical waves, which may be called the tidal waves, from the south polar region. They first come, expanding as a ring, from the south polar basin, and move in the same parallels of latitude, until they strike against Van Diemen's Land and Terra del Fuego (two opposite places), nearly at the same time; then they become divided, and diverged from their normal, circular, and latitudinal course by the configuration of the islands and continents.

This undulating stream impinges on Cape Horn and becomes divided. The current sets northward on the coast of Patagonia;—a bottle thrown into the sea off the Cape in 1837 was picked up on the coast of Ireland. The Chilian branch, after coasting Peru, becomes bent to the north-

west, owing to the shape of the coast, and is considerably dammed, thus causing a much greater tide, and a kind of circular movement between the Gulf of Panama and the Galapagos Islands*.

From this place it proceeds in a north-westerly direction towards the Sandwich Islands, and there meets the stream coming from the Chinese Sea, or the Japanese current on its way to the north. In the Pacific, the tidal wave is not so much interrupted in its course as in the Atlantic; hence this ocean is much more calm, and subject to less tidal oscillation than the Atlantic and Indian Oceans. At Campbell Island, to the south of New Zealand, the current frequently runs at the rate of about ten miles per hour, the same as along the west coast of South America; but the great expanse of the ocean at the equator diminishes the velocity, and owing to the various changes in the direction as above explained, a large neutral space is formed embracing the Polynesian Islands, where scarcely any stream is detected, and where a small tidal wave is seen only every twenty-four hours. [See New Ireland.]

Hence this is the region of calms—the sea of high temperature, wherein islands and sand banks are formed, and on which the corals grow in luxuriant clusters to great magnitude. The nautilus and various mollusca still abound here, the fossils of which are detected in sedimentary deposits in the northern regions. The islands in the Bay of Panama present also similar products, but on a smaller scale.

* The steamers running between Chili and Panama are obliged to have their coppers cleaned at the Island of Tobago, where the tide varies from 18 to 24 feet, in consequence of there not being sufficient tide at places further south to do so. The tides in Chili and New Zealand do not exceed 4 feet; in Auckland Island they are only 3 feet.

The tidal wave, as it strikes against the southern coast of Australia, proceeds in a north-westerly direction towards the Indian Ocean, leaving a small branch to separate and go between Van Diemen's Land and the colony of Victoria to the Pacific. The main stream, as it arrives in the Indian coast, causes high water on all sides almost at the same time. The tide at Van Diemen's Land, Australia and Ross Island, amounts only to 6 feet, but on being dammed against the coast of Bombay, it becomes much greater. The narrow Straits of Babelmandel and the protecting points of the east corner of Africa check its inland rush, and thus cause in the Red Sea a tide of only 6 feet. From this coast the stream bends to the south-west and forms the Mozambique current, running between Madagascar and the African Coast to the Lagulhas Bank, where it turns back to the north and unites with another stream from the south. A large portion of the great stream of the Indian Ocean enters the passages between the East-India Islands, the Chinese Sea, &c., and then flows northwards, towards Japan and the polar regions.

These bends, &c., cause a great circular movement in the Indian Ocean, somewhat similar, although on a lesser scale, to that observed in the Pacific, causing calms, banks and islands, which, like Keeling or Ross Island, favour the growth of corals, and on which the cocoa-nut and palm-trees are seen flourishing most luxuriantly. Ross or Keeling Island is formed in the shape of a horse-shoe, by the growth of corals. The bed of the sea within is somewhat shallow and flat, showing distinctly that it is not a volcanic production, although the shape might make it appear that such was its origin*. The great Atlantic cur-

* The coralline islands are generally famous for their springs of

rent or tidal wave, after bending round the Cape of Good Hope, proceeds along the western coast of Africa northward, at the rate of 10 miles per diem, causing tides of about 3 feet at St. Helena and Ascension Islands, until it comes in contact with the bend in the Gulf of Guinea, where it changes its course again to the north-west, and produces what are called the "Trades" of the Atlantic. One portion moves in the direction of the Bermudas; the other enters the Caribbean Sea along the Spanish main.

The latter is deflected by the Isthmus of Panama and follows the sinuosities of the coast line to the Gulf of Mexico; it then returns back to the open ocean, after a rotatory movement at the latter point. It comes out here as a warm, rapid current, known to mariners as the *Gulf Stream*, and deflects from the Straits of Bahama, in a north-easterly direction, towards Newfoundland and Norway. Before this warm current reaches the Azores, it separates into two branches, one towards Ireland and Norway, while the other flows in the direction of the Canary Isles and the western coast of northern Africa, thus forming a great oblong rotatory mass of water (similar to that described in the Pacific), and producing a great field of sea-weed.

The Atlantic current, in consequence of passing through such a long undulating path in the tropical zone, and being further heated in the Gulf of Mexico, carries very warm sea to the north-west of Europe, thus rendering the temperature much higher than is due to the latitudes.

fresh and cold water, in the middle of the ocean in the torrid zone, and present a very strong evidence of their having been formed by the action of submarine springs, forcing up mineral matter and forming cones like those of volcanoes. I have carefully examined them in the Pacific and Indian Oceans.

Part of the wrecks on the coast of St. Domingo have been found (carried by this stream) on the north coast of Scotland. Also casks with palm oil from wrecks off Cape Lopez in Africa have in like manner been conveyed to the north of Scotland. The winter cold of the most northern part of Scandinavia is ameliorated by the action of the Gulf Stream (running towards the north polar basin), which carries American tropical fruits, cocoa-nuts, &c., beyond 62° N. lat.; so also Iceland enjoys, from time to time, the genial influence of the diffusion of the warm waters of the Gulf Stream, far to the northward. Very slight alterations in the configuration of Africa, the Isthmus of the Darien, and Florida would cause great changes in the climate of Europe. The sea coasts of Iceland, like those of the Faroe Islands, receive a large number of trunks of trees and fruits from the tropics, periodically presenting unequivocal indications that the movement of the ocean is from the south. A very large quantity of sea-weed is seen constantly floating between the Bermudas and the Azores, within the limits of the neutral mass of water alluded to above; and corals also are seen fringing some of the Bermuda Islands. Some of the weeds, by the circular movement of this part of the North Atlantic, are carried back to the north-west coast of Africa, where the action is repelled again by the normal southern current.

The tides in the Caribbean Sea only amount to about 20 inches. They increase on the east coast of North America, and when the current comes in contact with Nova Scotia, and enters the Bay of Fundy, the tidal wave—in consequence of the damming effect of the land—oscillates to about 70 feet; whilst on the north side in the gulf of the St. Lawrence it scarcely amounts to 6 feet. The ob-

lique north-easterly current, on arriving at the British Isles, is exposed to similar effects; thus producing high tides in the British Channel and a circular movement round the North of Scotland to the German Ocean, until it meets a branch at Dover coming from the British Channel.

Inland seas are not exposed to the action of these oceanic currents; consequently they have no tides. Neither is there much effect produced on such seas as the Mediterranean and the Baltic, because their narrow straits are to the west and north, and not to the south. Inland seas, which are open to the south, are subject to the oscillations of the oceanic tides.

This will show how very inapplicable is the common theory of the tides to the actual movements of the ocean, and how very incorrect the knowledge of the tides must have been when such a theory was first propounded and accepted.

Diagrams Nos. 11 & 12 will show, at a glance, the general direction of the stream from south to north. It is very important that we should have a more correct knowledge of the currents and the tides than we have had, and some idea of the laws that govern them. Indeed, it is by the increase of knowledge on these important subjects, which has been acquired by mariners, and which are recorded in the practical sailing books, that circular sailing has been of late years so much followed, and such quick passages made to and from the Antipodes. The records of observations are our only guides in all these questions, and not the theories which have been propounded.

The ocean and its currents have been and still are important active geological agents in forming and modifying the configuration of the islands and continents, and in spreading the local deposits of great rivers over large areas.

Fig. 11.

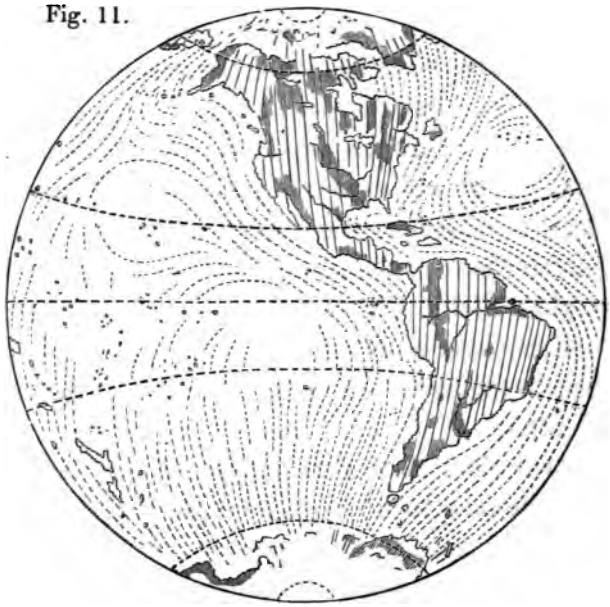


Fig. 12.

Shoals are increasing and diminishing according to the variable character of local conditions: even a slight alteration in the bend of a continent, or a break in an isthmus, would cause a very great difference in the temperature (such as Europe for instance), and thus change the nature of the deposits and render many parts unfit for the majority of the existing plants and animals within the limits of certain regions; under such circumstances they would have to retrograde south, to a more genial clime, or dwindle and perish like their predecessors.

Having now glanced over the main features of the globe, and the great operations that are perpetually at work, we shall proceed to investigate the consequent results in the same manner, and trace their general connection.

Sedimentary Deposits.

We shall now enter into questions more immediately connected with geological researches, in which there is so much discordance, and almost insurmountable difficulties, in reducing the valuable discoveries of the ancient organic productions into one consistent system.

The frequent new discoveries of organic remains, and the subdivision of sedimentary beds into distinct eras of long periods of time, &c., instead of advancing our science, appear to retard it, causing continual changes of a retrograding nature, and leaving the surrounding horizon darker than ever. Most important facts are constantly opposed, sometimes for many years, simply because they happen to be contrary to the doctrines which might be in fashion. Thus our Earth may become actually girded by the practical application of the law of Magnetism;—natural Chemistry may be applied in our manufactories—to the enrichment of the soil and nourishment of plants, to improve the soil

and our agricultural industry—and our minerals may be discovered and converted into new purposes of life; our ships remodelled, the course of our circumnavigation changed; in a word, the whole of our *industrial* science may proceed centuries in advance of the *theories* of science, which are pertinaciously kept behind instead of progressing and aiding us in the march of improvements and discoveries.

In commencing the geological inquiry of the sedimentary beds, we shall consider, first, *the universality of the different geological formations.* Amongst the various theories promulgated by geologists, none have given rise to greater discussions, and led to the idea of successive creations, more than the one which maintains that the entire surface of the globe has been covered by separate and consecutive concentric layers or envelopes, enclosing distinct and different orders of organic beings, which were considered to have existed at long intervals of time; and as these were supposed to have been destroyed and terminated, each covering in succession required a new creation.

The bad effects of this doctrine are felt even in the present advanced state of geology, inasmuch as many persons still believe that the earth is universally so covered, and that the sedimentary deposits and the order of the organic kingdom are precisely the same in the Southern Hemisphere as in the Northern.

The fact is, the only rocks which may be considered as universal are the crystalline, *i. e.* the granites and the schists, as already described. These are found everywhere on the face of the globe, and always exhibit the same general character.

As regards the sedimentary rocks, from the oldest to the most recent, they are only found very partially, and are

Fig. 13.

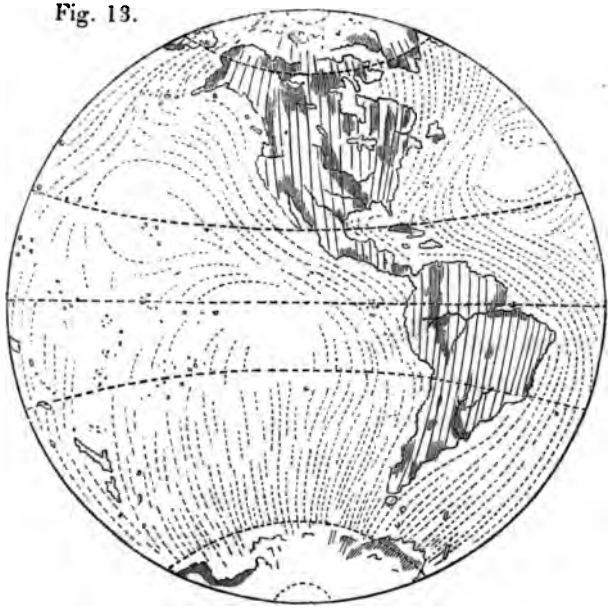


Fig. 14.

Fig. 13. The dark spots exhibit the sedimentary deposits of the Western Hemisphere, and fig. 14 the deposits of the Eastern Hemisphere.

necessarily extremely local, as shown in figures 13 and 14. A mere glance at a geologically coloured globe will show how insignificant is the extent of the area of the carboniferous formation, as compared to the entire surface; the same may be said of every division of the sedimentary series from the lowest to the highest. Yet these sedimentary rocks are so subdivided throughout into distinct groups by European geologists, as to make it appear that such was the normal and not the exceptional state of things in other parts of the world.

As our investigations have extended to distant regions of the earth, more especially to South America, Australia, Africa and India, new combinations of beds have been brought to light, showing the total absence of almost two-thirds of the grand series represented in the ordinary geological sections.

The limits and breaks which have been assigned to different formations in the countries where first observed have not been found to hold good in other regions. It has been observed that between these demarcations, as at first laid down, certain fossils of the lower beds extend higher up into those above, while some of those hitherto supposed to be characteristic of the overlaying formation are found extending downwards into beds of an older period.

This gradual transition of one variety of fossiliferous beds into another is rather the rule than the exception, and is a *vexata quæstio* between two distinguished geologists, and must continue to be so whilst any attempts are made to separate the Silurian system from the Cambrian by their organic contents.

There does not appear to be any probability of finding a definite line of separation, as a careful examination tends

to prove that the whole formation belongs to one organic system, from the old red sandstone down to the primary rocks; and were such a line to be found, stratigraphically, it would only be of local importance, and not applicable to other parts of the world.

These minute subdivisions have already caused the waste of valuable time, and considerable injury to the progress of the science: it is to be hoped that the subject will be freed from such endless discussions on trivialities, and that it will receive more attention in its more comprehensive character instead of being so much confined to the somewhat useless creations of the sedimentary beds into so many distinct systems.

To proceed with our subject.—In pursuing our researches we do not find similar development of sedimentary rocks in each geographical zone. In the Northern Hemisphere it is true we recognise, both in Europe and America, an immense series of highly consolidated deposits characterized by organic remains of different climes—of the south temperate and tropics in succession,—but the sedimentary deposits of the Southern Hemisphere are neither so numerous nor compact, and their organic contents in general bear strong analogy to those now existing in that region, without a trace of organic remains belonging exclusively to the north.

Were this most important geological fact better known and attended to by geologists, they would be much more guarded in their generalizations, and in order to prepare the reader to form a correct opinion on the subject, and to remove at once the idea of the existence of the same kind of sedimentary rocks over all parts of the world, as those which we find in Europe or the Northern Hemisphere, we shall begin to describe them from the south; first, in the

South temperate; secondly, Torrid; thirdly, North temperate; and, finally, in the Arctic region.

The Sedimentary Rocks of the South Temperate Zone.

The first thing that strikes the observer in travelling over the plains and sedimentary terraces of Patagonia and the extensive sandy desert of Australia, with its limited sedimentary beds on its south and eastern flanks, is, that these dry lands are of comparatively recent origin.

The majority of the lagoons contain brackish water; the marine shells which are found scattered over the surface, if not identical, are at least so like those now existing in the bordering sea, as to be considered the same by all ordinary observers. The great siliceous trees are also apparently identical with the existing conifera of this zone. Although the vegetation is so strong and luxuriant in this hemisphere, yet the new gravelly lands that emerge from the ocean require centuries before the vegetable world clothes the dreary scene, unless they are connected to a pre-existing continent. The lands in the South Frigid and Temperate zones change their aspects almost suddenly from the barren wastes of the Antarctic to the rich and gigantic foliage of the South temperate.

There is no intermediate organic or vegetable band analogous to that which we see in the north; the change is abrupt from the frigid to a semitropical aspect.

The sedimentary rocks of Australia within the confines of this zone are very limited, and are only found in a few small patches in South Australia, Victoria, Van Diemen's Land and New Zealand, but more extensively in New South Wales. In the latter portion of Australia, bordering its

eastern flank in the neighbourhood of Sydney, we find the carboniferous formation with its sand and calcareous beds resting immediately on the edges of the primary crystalline rocks, and cropping out along the western side of the Blue Mountains. This coal formation may be seen from the Hunter River to Brisbane Waters. On reference to figures 13 and 14, it will be observed that the sedimentary deposits of the coast conform to the direction and bends of the ocean currents. Seams of coal have been also found on the southern shores in the colony of Victoria—in Western Port and Cape Otway. The same formation extends as far as Geelong and Portland, but with only very thin seams enclosed in sedimentary clay slate. This, like the New South Wales formation, is immediately in contact and resting on the edges of the crystalline rocks, having neither an intervening system of beds below, nor yet above: the whole appears as one group of deposits.

On referring to the entombed organic remains in the sedimentary beds, we find that the fern trees, cycadeæ, araucariæ, &c., are the characteristic fossil flora, and although attempts are frequently made to separate the species from those now flourishing in the same region, yet those who are unbiassed by any theory cannot distinguish the difference between the living specimens and the impressions in the beds.

It is not easy to determine the species of living plants of an unexplored region from imperfect fragments: how slight is the clue in many cases afforded by a leaf; and how hopeless is the task when the botanist has before him only the fragments of a stem! Yet such are the materials from which, in nine cases out of ten, the describer of fossil remains constructs his extinct and new species.

Let us turn to Patagonia and Chili. There we find the

tops of the mountains covered with the shells of the neighbouring sea, and the fossils of some species of the araucaria, conifera, &c., which still flourish on the land. On traversing any of the sections in Patagonia, from the Rio Santa Cruz to the base of the Cordilleras, and again on the Rio Negro, we find the whole of the sedimentary series of recent origin, and irregularly covering, or deposited on, the edges of the primary slate and granites. The shells and corals of the lowest deposit are those which belong to the bordering sea. Although it is difficult to distinguish some of them from the species found in the Silurian rocks of Europe, yet they are littoral species of the neighbouring coast, and are frequently found scattered at various heights from 1300 feet downwards. The whole of this country, like Australia, indicates a comparatively recent and gradually slow elevation from the deep; such uniformity of terraces could not by any means be produced by convulsive movements. It will, therefore, be observed, that the sedimentary deposits of the South Temperate Zone are comparatively very limited and recent, and that their organic contents correspond, more or less, with the existing state of things within that zone; the slight variation being no more than that which must naturally arise from the changeable physical conditions of the different localities, and the variable currents of the ocean.

In New Zealand, as in Australia, the fossil remains of the extinct animals are associated with those of the existing genera; and the land is still inhabited by diminutive representative forms of the colossal beings which flourished there in early times. New Zealand, like Australia and Patagonia, has undergone physical changes by which the areas occupied by the ornithic ossiferous deposits, and the beds of shingle and loam have been elevated, and now form

terraces from 50 to 100 feet above the sea level. The relics of gigantic birds prevail in the fauna of New Zealand as in all the new southern lands, to the almost entire exclusion of mammalia and reptiles, accompanied by ferns and club-mosses, thus showing that it had not been as yet connected with a pre-existing continent, with quadrupeds and other terrestrial animals.

Should New Zealand subside and be emerged again, it would be inferred that its organic remains belonged to another world that did not contain any other animals than the relics represented. This island presents a general correspondence with the lands of the carboniferous epochs, and is strongly impregnated with carbonaceous liquids, which crystallize into seams of bituminous beds. The same kind of productions are only seen in Van Diemen's Land and many parts of Australia, and used as coal.

Australia and Van Diemen's Land, in consequence of the abundance and variety of the cycadeæ, araucariæ, &c., the marsupial character of the great proportion of the mammalia, and the terebratulæ, trigoniæ and the cestraceous fishes which swarm in the seas that wash their shores, produce deposits with relics like those we find in the carboniferous and oolitic formations, which will hereafter become sedimentary rocks like those now seen in Europe.

The Deposits of the Torrid Zone.

The portion most available for examination in this zone, with the exception of a part of India, is South America. Here we have the advantage of a very extensive and continuous series of sedimentary beds, which can be traced, more or less, from the south, to the shores of the Caribbean Sea. These sedimentary rocks are intersected by very

deep ravines, presenting every facility for making minute examinations.

The author has made numerous large Sections, one of which is shown in Plate VII. He presented the Geological Society with some of the fossils in 1843 which are described in the Geological Proceedings, vol. IV., No. 101. This section represents the rocks near the equator, where the series of sedimentary beds can be well seen; they are largely developed, and elevated to about 11,000 feet above the level of the sea.

Commencing the examination below, we find the usual, and indeed universal-base, *i. e.* various bands of crystalline rocks on edge, and running north and south, on which the sedimentary beds are formed, in some places as beds of sand, and in other parts clay, pebbles, or large boulders with but very slight traces of organic remains, varying according to the nature of the locality and sea bottom on which the beds were deposited.

Ascending the series, we come to beds of sandstone and clay-slate, more consolidated than those of the previous zone, but containing shells so much like those found in the South Temperate Zone as to render it impossible to separate them as a whole. We next come to a series of sandstones, dark compact limestone and seams of coal, with impressions of plants in the shale and clay presenting more of the South Tropical aspect than that of the Torrid Zone.

The shells, corals, and ammonites are somewhat abundant in this formation, some of which have been described by the late Prof. Edward Forbes*. The living representatives of the ammonites have not been discovered, but the

* Geol. Proceedings, vol. iv. No. 101.

other shells, nautilus and corals, are analogous, if not identical with those seen in the southern seas.

The upper beds of this formation predominate in sandstone, which are somewhat barren of organic remains; but in the debris over the surface and in the ravines are found a great variety of ammonites, varying from an inch to three feet in diameter, with oyster and other shells, fossil wood, and fossil bones of gigantic saurians and other animals.

These are found along the plains for many hundreds of miles north and south of the equator.

In the gravel beds, are also found the remains of crocodiles, sharks, fossil trunks of large trees, and of the plants which are still living in South America on the banks of the Amazon, Orinoco and the Galapagos Islands.

When we take a general view of the physical conditions in which we find the above series of sedimentary rocks and which form such a large portion of the eastern branch of the Cordilleras, for thousands of miles north and south, we cannot arrive at any other conclusion than that the deposits were formed in inland seas, that the whole has been gradually and somewhat uniformly elevated to the present height (say 11,000 feet above the level of the sea), and that such continuity—unbroken beds for so many miles in extent —could not have been produced by volcanic eruptions, or any other convulsive force.

Indeed, had geologists the opportunity of witnessing the constant mutations now going on along the coast of South America by the slow and imperceptible elevations and subsidences, causing great geographical changes, they would have no reason to have recourse to their favourite theory of prodigious cataplasms, or paroxysmal upheavals by internal fires.

On minutely examining the beds, we do not find the organic separations and the common breaks established by geologists; on the contrary, we see a gradual transition from the inferior to the superior beds in their organic contents; hence, to produce such deposits as we find—and admitting that the organic conditions of the respective zones have remained unaltered,—it requires two movements, viz., a vertical one from the level of the sea, and a *longitudinal one from the southern zone*, to account for the apparent difference of the organic contents of the deposits below as compared with those above.

If we admit one movement, viz., the vertical oscillation, there can be no difficulty in admitting the horizontal or oblique movement, especially when we find that it is the only way by which we can account for such variable organic deposits according to the existing laws in the œconomy of nature.

Further proofs of the necessity and the real existence of the two movements will be found as we progress in our inquiry. It may be argued, that the south currents, explained above, would alone be a sufficient cause to account for the organic remains of the south being deposited at the equator and northern region. The oceanic movement from the south doubtless explains the origin of some deposits; but those which indicate that they have *lived and died on the spot in which they are now entombed*, require an action different to that of mere currents of water. The lands as well as the ocean must also move *en masse* to account for the phænomena.

In Malacca, Singapore, Borneo, Sumatra, Java and Ceylon, the sedimentary rocks are but slightly developed, forming a small and very partial covering, on the edges of the primary rocks; the organic remains, as far as they have been examined, correspond with those existing in the Indian

Ocean and Southern Islands. Scarcely any organic remains are found in the ferruginous beds of Malacca; the primary rocks here are almost bare. In the Indian Peninsula, and more especially in Bengal, there is almost a total absence of fossiliferous rocks, and the coal-basins are found, like those of New South Wales, deposited immediately on the edges of the gneiss and schists, first as beds of conglomerate, then shale, limestone and coal, with ferruginous clay beds without any trace of the Cambrian, Silurian and Devonian rocks of England. The slight impressions of plants, that can be detected in the clay seams and shale, are analogous to the ferns of the south temperate region already explained. This portion of the Torrid Zone has a greater number of breaks, &c., than that in South America, and is consequently more subject to diversified deposits. The Philippine Islands contain small carboniferous deposits, but generally speaking these islands present the usual variety of crystalline rocks, uncovered by sedimentary beds.

The Malay Peninsula, Ceylon and Hindoostan, have only a few isolated patches of sedimentary deposits, and although they do not contain any large amount of organic remains, those detected correspond with the marine and terrestrial fauna and flora of the Southern Hemisphere. Arabia and Africa, so far as these countries have been explored, are but slightly covered by sedimentary rocks. There are beds at the Cape of Good Hope, which more or less correspond to the carboniferous, and conform in some degree to the configuration of the bend which the current of the ocean has at this point. The interior of Africa, like that of Australia, appears to predominate in a sandy desert. The isthmus of the Darien, Guatamala, and the West Indies, are also somewhat scantily covered by sedimentary beds.

The Coral Islands and Reefs of this zone deserve our particular attention, as showing how the calcareous springs, &c., are collected and deposited at various centres in the ocean. The corals live and flourish from the very margin of the south polar basin even and extend to the north Temperate Zone, but it is in the southern portion of the Tropical Zone that we find them growing like forests of stony plants, from the forms of sponges and mushrooms to that of gigantic cauliflowers and trees. The Indians, or the natives of the hot countries, call corals "sea-plants" and "rock-flowers," and smile at the idea of their being considered as the production of marine animals.

Corals are, as it were, protected and cultivated at Ceylon, the islands in the Pacific, and numerous other places, for the purpose of obtaining lime from them, where limestone beds do not exist. In and near Torres' Strait there are many coral reefs; there is one extending from Breaksea Point, on the eastern coast of Australia, to Briston Island, off the coast of New Guinea—a distance of 1000 miles more or less in the meridian, and 30 miles in breadth. This reef is growing on one of the ridges of the primary series.

There are several others of the same character running between the north coast of Australia and New Guinea, which are infested by gigantic sharks. Shells of large size and great beauty, including several species of the nautilus, are found in this region, and are daily buried in the sand and calcareous mud of the lagoons, forming oolitic and cretaceous beds for future generations.

The corals of the Maldive Islands grow on high ridges of the primary slate, from Chagos to the coast of Bombay, about 23° of lat. The edges of the primary rocks, and especially the gneiss with hornblende bands, appear to be

peculiarly favourable to the growth of corals, when they approach within a few fathoms of the surface.

Many of the coral islands called *Atolls*—such as the Keeling or Ross Island in the Indian Ocean—are formed by the cones made by submarine freshwater springs; hence they are favourable spots from whence to obtain this desirable element in the Torrid Zone in the middle of the ocean. It is true, that some of these submarine springs, on their first bursting out into the saline compound, appear to have become inflamed, and to have melted the rocks on the margin of their passage. Such was the case during the emersion of the Island of Taboga, near Panama in the Pacific; but this inflammatory action (which is probably produced by the hydrogen and chlorine) is the exception; upwards of 96 per cent. of the coralline islands being produced by the aqueous springs of fresh water alone. These latter are very numerous in the Hebrides and the Caroline Islands. The growth of corals extends as far north as the Bermudas, owing probably to the warmth of the Gulf Stream. They are found in great masses in the Caribbean Sea. The island of Barbadoes is a consolidated mass of coral.

Portobello has been entirely built of coral rocks that grow on the hornblende rocks of that coast. Corals contain from 90 to 95 per cent. of lime, and may be truly called calcareous plants.

It is a very interesting fact, that the action of the sap of corals, vegetables, and the oscillations of the tidal waves, accompany the changes of the moon as regularly as clockwork, within the tropics; these important facts, together with the diurnal oscillations of the barometer and the magnetic needle, will be noticed separately with various other meteorological phænomena.

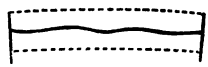
In connexion with submarine cones forming what are called Atolls, which are fringed with corals, it would not be irrelevant to notice also the sub-aërial cones of similar character, which are called by the Spaniards "volcanoes de agua." A very interesting example may be seen near Carthagena in New Granada.

The superficial formation is principally composed of coralline rock, partially changed into a porous calcareous crust, and mixed in some places with sand, gravel and seams of sulphate of lime.

On this formation are the celebrated "volcancitos of Turbaco," which are small cones, situated on a rising ground, discharging aqueous and gaseous matter. They appear to have been produced, and are still partially kept in action, by springs of water confined underneath by the calcareous cap. Each of these miniature volcanoes has a bubbling action, but the temperature of the water is not higher than that of the surrounding air, say from 86° to 100°. The water has a saline taste, and is slightly aperient; it contains carbonic acid and sulphate of soda. The mud discharged and deposited on the margin of the cones and craters, is very black. Nicaragua contains also many "volcanoes de agua"—it may be stated as a fact that the Western Hemisphere predominates in them—scarcely containing 2 per cent. of the igneous variety when in a state of activity. Indeed, the fiery cones are the exceptions in all parts of the globe; they only become inflamed, when disturbed by local chemical causes, whereas the aqueous cones are innumerable and almost everywhere, and are always active, supplying the sea, the vegetable and the animal kingdoms, with many of the essential elements from the interior of the globe.

The apparent disturbing action of these springs and their

varied productions from pure cold water to impregnated mineral compounds have not been sufficiently attended to; far too much importance has been attached to the exceptional phænomena of incandescent volcanoes, in questions connected with geological dynamics, which are, after all, when compared to the size of the globe, but mere microscopic pimples. The annexed diagram exhibits the undulation of the surface from the highest mountains to the deepest seas, in proportion to a portion of the globe 500 miles in length.



The Sedimentary Rocks of the North Temperate Zone.

This division will embrace North America, from Mexico to the Arctic Regions, Europe, Asia and the northern portion of Africa.

On reference to the general view of the two hemispheres, it will be observed that the sedimentary series of rocks is more developed in this zone than in any other portion of the globe, but more especially in Europe.

Commencing our investigations on the shores of the Pacific, we find the primary series only very partially covered by sedimentary rocks along the coast of California. To the north, in Vancouver's Island, there is a carboniferous formation with impressions of plants analogous to those now flourishing in Chili. The following transverse section from

Fig. 15.

the Pacific to the plains of the Missouri, will give an idea of the primary series, and the superficial sedimentary covering.

The primary rocks are more or less exposed from the Valley of the Sacramento to the east flank of the Sierra Nevada, and are traced on edge running north and south for hundreds of miles—like the structure of all gold regions, and only covered by the crystalline debris. Between the Nevada and the Oregon Mountains, the surface is covered by the debris of the primary rocks and sand; in this basin are numerous saline lakes. The Oregon Chain to the Rocky Mountains is composed of the usual series of primary rocks on edge running more or less north and south, from Mexico to the Arctic regions; and on descending eastward towards the plains of the Mississippi and the Ohio, the whole is thickly covered by deposits of comparatively recent origin, enclosing bones of the mastodon and the buffalo. The mountains of the Sierra Nevada, especially in Nappa, have numerous "volcanoes de agua." The apertures in the mountain sides frequently resemble the Geysers of Iceland in the roaring and hissing of the vapour issuing from them. In some, the bubbling waters are so hot as to scald the hand, while not far distant, springs discharge water almost as cold as ice. Mineral springs of all kinds abound in this region—sulphur, alum, carbonate, and chalybeate waters. A piece of wood placed in one of these springs soon becomes encrusted with silica and calcareous matter. Bituminous springs form also beds of jet, and crystalline beds of a dark carbonaceous substance. The process of the formation of limestone, from calcareous springs, can be seen going on daily in these regions, similar to that now forming in various parts of South America. Salt is also found in large masses, on the plains between the great ridges.

A gentleman who had visited the above region writes—"The fountains lay open at one view, the extraordinary

operations of subterranean heat caused by chemical action, instead of the mistaken idea of volcanic fire or igneous globe. In one place, about 40 miles from the mountain first above mentioned, one of the party broke open a hard rock of shell limestone, and found in it a perfect shark's tooth with serrated edges precisely like the living species of the Pacific coast. In another place he broke open limestone more recently formed, in which were enclosed land snails or helices, with perfect shells, and petrified trees, &c."

The fluviatile deposits of the Missouri and Mississippi contain land and fresh water shells of local species, with a considerable proportion of tropical productions.

It is extremely probable that the Gulf Stream ran formerly in this direction to the Arctic Regions, and thus conveyed a large amount of tropical vegetation, &c., and deposited the same in the mud of the valley of the Mississippi. Very great changes have taken place during the last 250 years from the Isthmus of Panama to Florida, the whole of which is still rising. Both the Isthmus of Panama and the Isthmus of Suez are covered in several parts with shells belonging to the South Pacific and the Indian Ocean; thus showing that their emersions respectively are, geologically speaking, of a recent date. Drifted productions of the tropics and the Southern Hemisphere, carried by the oceanic stream northward,—in various directions, according to the altered configuration of the dry lands, may,—it is true, account for a great many of the organic remains which we find in the deposits of the Northern Hemisphere; but such operations are not sufficient to cause an entire south tropical forest, with its accompanying animals, to be conveyed to the north, and to become gradually enclosed there in sedimentary beds of different climes and periods; neither

are these merely isolated effects: they are found to prevail throughout the northern hemisphere in North America, and in Europe, to the confines of Asia and the north polar basin; therefore nothing less than a movement *en masse* northward, carrying forward all the organic system with it from zone to zone, can account for such phænomena as these. These deposits are not irregular or at any time inverted, such as the deposits of the north lying under those of the south; on the contrary, we first find underneath the deposits of the southern products, then of the tropics, and lastly those of northern latitudes, one on the other, in succession and strictly in accordance with the result of a movement from the south to the north; thus we find the land conforming to the direction of the general movement of the ocean. In discussing questions like these we must dismiss from our minds the *present* geographical distribution of sea and land, and bear in mind the numberless elevations and depressions of the land that must have taken place, since the creation or the commencement of the older sedimentary deposits which have been brought from the south, and which are now merging into the north polar basin.

Proceeding eastward towards the Appalachian Range, the carboniferous deposits are found developed in long trough-like shapes, nearly parallel to the bordering primary ridges. Some of the coal-beds are about 35 feet thick. The carboniferous basin of Eastern Virginia is composed of sandstones, shales, &c., deposited on hornblende, slate and granite.

The sedimentary deposits of the United States, Cape Breton, &c., contain upright stems of Calamites, Equiseta, Lepidodendrum, and a great variety of Ferns, similar to those found still growing in Patagonia and the Brazils; and their fossil condition shows most distinctly, that *they grew*

on the spot where they are now entombed. Many of the fossil trees were also hollow before the mud—which now forms the shale—was accumulated round the plants. Hollow trees are peculiar to the South Tropical Zone: in Patagonia and Austr ''', whole forests of hollow trees are very common.

The following section will give an idea of the structure of the eastern part of the United States, across the Appalachian chain of mountains.

Fig. 16.

The Americans have subdivided their sedimentary rocks somewhat differently to the Europeans, and as their deposits (stratigraphically) do not correspond with the sedimentary beds on this side of the Atlantic, they have a right to adopt their own local systems, provided they do not carry them beyond their proper limits. It is, as already observed, very injurious to the progress of geological science to attempt to form general systems of equivalent deposits which could not possibly have existed under the various distribution of sea and land, and the numberless elevations and depressions going on. The proofs of such changes are incontestable, showing how necessary it is to bear in mind that the altered physical conditions, at different periods, influence the character of the local accumulation of detrital matter. However convenient the subdivision of beds may be for local purposes, such a partial system should be avoided in discussing general questions; we should adopt a much larger grouping, when we compare the deposits of distant regions with one another, even in the same parallel of latitude, much more when we examine the deposits of different zones, at different intervals of time.

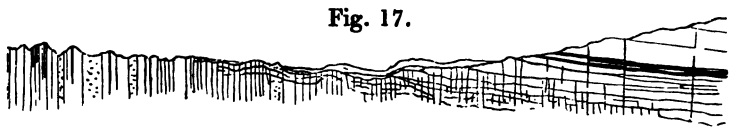
For our present purpose it is sufficient to state that the sedimentary beds of the United States, from the lowest to the highest, contain the organic remains which correspond with the South Temperate Zone and the tropics; and that *these remains lived and died on the spots where they are now found, at the time of their deposition, and when the land was in more southernly climates.*

The primary series is seen more or less on edge in this part of the States, and can be traced from Florida along the Appalachian Chain, to Canada, Nova Scotia, &c. The same kind of primary structure is also seen north of the Lake Superior; but as this subject has been already noticed, we shall proceed to the consideration of the formation of Europe.

The Sedimentary rocks of Europe have been so attentively examined, and so carefully divided into several systems of deposits, that it is only necessary to name the principal groups in the ascending order, and to note the character of their enclosed organic remains, to serve the object of this introductory discourse.

These groups are called the Cambrian, Silurian, Carboniferous, Oolitic, Cretaceous and Tertiaries. The annexed section will show their relative position, and the effect of the vertical structure of the primary series, in obliterating, intersecting, and contorting the old sedimentary beds below.

Fig. 17.



In examining the organic remains of Europe, we find

precisely the same indication of a change of climate from the south to the north as elsewhere; the fossils are not simply the relics of drifted organic remains from the south, but gigantic plants of the Southern Hemisphere, in a perfect state of preservation, with their roots still attached to the consolidated soil; which may be seen in the coal formations of England, Bohemia, Saarbruck, &c., in the positions in which they grew: many of these plants cannot be distinguished from those still existing in Australia.

Dr. Hooker's observations on this subject fully bear out the analogy.

The *order* of succession above indicated is found to be constant all over Europe. Not that all the members of the series are universally diffused and always present; on the contrary, there are but few spots where the *whole roll* of the sedimentary rocks is seen lapping one on the other without a break; yet the ascending sequence is invariably the same. The *organic aspect* of the Cambrian and Silurian Systems is not by any means different to the present aspect of the zone bordering the Antarctic region. The latter zone presents a barren and desolate scene: nothing but a few shells and corals can become deposited in that portion of the globe. The genus Serolis is a near approach to the external form of Trilobites, and the beach in the Straits of Magellan is often seen covered with dead Serolis, which are only found alive by dredging in deep water. Many of the broken shells and corals of this desolate region have a striking resemblance to those found in the Silurian rocks. On ascending to the Carboniferous system, the organic aspect changes almost abruptly, from a scene of marine barrenness—mere shells and corals—to that of a lacustrine and terrestrial vegetation of a semi-tropical cha-

racter, and consequently somewhat abundant in organic remains; thus indicating the most complete accordance with the varied conditions and great contrast between the organic systems of the Antarctic and the South Temperate Zones.

Were a Patagonian geologist to come to Europe to examine the contents of the sedimentary beds, he would not be surprised at seeing the different organic aspects of the beds, nor would he assume the unnatural conditions of the universal spread of each of the organic systems, with repeated destructions and new creations, but would be governed by the existing order of things and natural analogies, and would necessarily attribute the change to what he was accustomed to in the Southern Hemisphere. There is no spot on earth where the deposits could obtain in the same region an assemblage of all the existing organic kingdoms. Every region from zone to zone, and from the bottom of the sea up to the inferior limits of perpetual snow, has its peculiar fauna and flora; therefore why should we conceive the existence of a different order of things in ages gone by? Since such is the law of the organic distribution, it is quite evident that nothing short of a progressive movement of the land from zone to zone, *i. e.* from south to north, could produce such a collection of organic remains as those now found in the sedimentary rocks of Europe. Every day is adding to our knowledge of the varied distribution of the living system, and the perpetual disturbing and renovating action of the Earth's surface, by submerging and emerging from the level of the ocean. During the past epochs, when our oldest rocks were deposited, the same physical laws prevailed; therefore why should we invent unnatural systems, when we find that the laws of existing nature account for all the phænomena we observe in our rocks?

It would be as unnatural to find cocoa-nut trees and bamboo mixed with the organic remains of the Silurian rocks, as it would be to see pine-apples and sugar-canes growing in the open air amongst the cabbages and potatoes in the northern region. If then we name each system of sedimentary beds according to the zones in which it is herein assumed and maintained that the beds were originally deposited, we find all the apparent discordances and difficulties vanish, and the whole at once presenting a complete and consistent natural system of deposits. Let us take, for example, the following European series of sedimentary beds, from the Silurian to the Tertiary, and compare their contents with the deposits now accumulating in the respective zones.

Local names.	Zones where the beds were deposited.
1. Silurian	Antarctic.
2. Carboniferous	South Temperate.
3. Oolitic	Ditto ditto.
4. Cretaceous	South Tropic.
5. Tertiary	North Tropic.

On reference to each system of beds, it will be observed that there is a perfect agreement between the organic aspect of the deposits and the existing state of things, and that a slow undulating movement of the surface of the earth in transit through different climes, in conformity with the polar force and the movements of the ocean, would produce the results observed.

The oolite formation presents the South Temperate aspect in all the beds. The crocodile, scorpion, and other reptiles, and fishes corresponding to the south have all been found, not only in the lias and oolite, but also as low down as the coal formations on the Continent. At the period of the lias, the vegetation was similar to that of the Southern

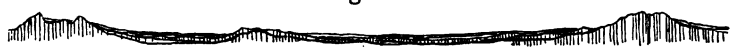
Hemisphere, not only in the simple fact of the presence of Cycadeæ, but the pines herein imbedded were also of the nature of species found only to the south of the Equator.

It is not in strata where the organic remains belong to extinct species, but where the living species abound in a fossil state, that the question of a gradual geographical change can be subjected to the *experimentum crucis*. The fossils of the Subapennine hills, and their living analogies from the tropics, correspond in size; but the individuals of the same species from the Mediterranean, are dwarfish, and appear degenerated and stunted in their growth, for want of the physical conditions which the Indian Ocean still supplies. Whenever any of the fossil shells are identified with living species at or near the Equator, it is not in the Northern Ocean, but in the Southern Ocean, that they must be sought. The same may be said with respect to the fossil sharks in the sandstone beds of Malta.

We need but refer to the description of the sedimentary beds of Europe and Asia, and their organic contents, to obtain the evidences of a northward action throughout.

To the north—in Scotland, Norway, Sweden, Iceland, the Ural, and part of Siberia,—a great portion of the primary series is uncovered by sedimentary rocks. In Norway, Sweden and the Ural, the primary rocks are found in their normal position, on edge, and running more or less north and south. The following section will give a general idea of the formation, from the west coast of Norway, to the plains of Siberia:—

Fig. 18.



The elevation of Russia has been remarkably uniform

and gradual, and the sedimentary rocks not disturbed and dislocated like those of Western Europe in the Alps, &c.

Volcanoes.—Although Vesuvius and Etna have been very active igneous incandescent volcanoes, we find that they are the exceptions in this zone as in other parts of the world. The volcanoes of Iceland may be traced from mere springs to gigantic cones. The Geysers may be divided into two main groups, according to their chemical properties, one of which comprises the acid and the other the alkaline silica springs. The springs are found hot and cold, and contain soda, alumina, silica, chloride of sodium and sulphate of soda.

The hot springs of India are the same; and in short, all the pores or terrestrial pimples, from the size of a mole-hill to that of the magnitude of a volcanic crater, are only different in their dimensions, and not in their aqueous character, being the effects of active local condition, generated by the elements of the sea and the crystalline base. The volcanoes are commonly found in meridional lines in the direction of the primary structure, as Etna and Vesuvius, and the directive force of Earthquakes follows the same course. The undulations and vibrations of the surface are frequently propagated along the primary structure from Chili to the Caribbean Sea, a distance of many thousand miles.

The Arctic Region.

We can only examine the margin of Europe, Asia and America in this region; still even here we find sufficient proofs of the changes which have taken place on the surface of our globe.

Greenland, a thousand years ago, enjoyed a mild climate and contained a large population.

Numerous subterranean stone labyrinths have been discovered in Lapland, Nova Zembla, Spitzbergen and some of the islands lying near the coast of Finland, particularly in the desert of Wiez, giving strong proofs of former habitations in these dreary parts, that have so long since passed into oblivion. Trunks of trees, with their roots attached to the soil, proving that they once grew on the spot, have been found far in the Arctic region; stems of Palms, and Elephants with their skin and hair still preserved, are found buried in the interior of the earth in Northern Europe and Asia. Numerous other evidences may be brought forward to show that great changes have taken place during our historic period, and that these movements are still constantly going on, carrying the lands to the inhospitable clime of the north; their respective inhabitants either dwindle and perish, or retrograde southward like their predecessors. Hence the cause of the world being always populated from the North. The sedimentary rocks that have been examined on the west coast of Greenland, Baffin Bay, Melville Island, &c., contain marine shells and terrestrial plants analogous to those which are still flourishing in the South Temperate regions.

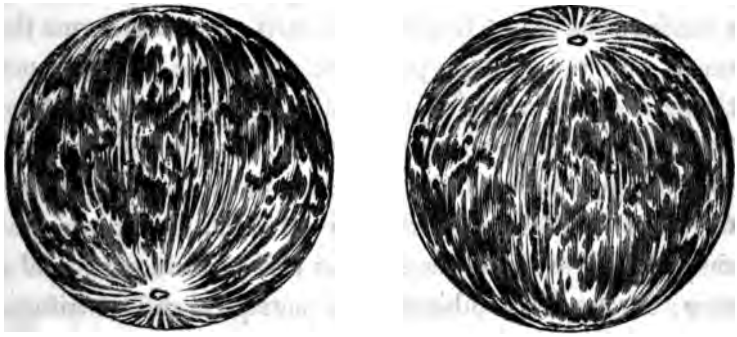
Having now glanced over the universal character of the sedimentary rocks of each zone, we shall next draw attention to the general aspect of the globe, when viewed in connexion with its poles, primary structure, the oceanic streams, and the white aërial luminous meridional bands which are often seen stretching from pole to pole, on clear nights, within the tropics, during the period of the polar lights. Were it possible to view this phænomenon at a distance, the globe would appear at times like a gigantic

fruit or a melon with its meridional bands or polar structure.

It is also a fact, that our satellite presents the same kind of fruit-like appearance similar to the radial symmetry of an orange near its stem, as will be seen on reference to the following sketches, which represent a telescopic aspect of the moon. [The Frontispiece plate is an exact representation of the Moon as seen from the Southern Hemisphere.]

E.

N. S.



E represents the earth with its north pole towards the Sun (in June); N the Moon as seen in the meridian from Europe; S the Moon as seen from Van Diemen's Land.

The visible pole of the Moon (which is always pointing to the south pole of the earth) is very striking, and the meri-

dional or polar structure, or rather the luminous meridional bands, are beautifully displayed in the clear atmosphere of the tropics, showing very plainly that our satellite is governed by the same law of polarity as our earth. The sketches are only intended to represent the general aspect and the different position of the pole of the Moon as seen from the north and south*. According to the well-ascertained laws of Magnetism, the visible pole of the Moon must be her north pole, and therefore it serves as a very interesting spot, to enable us to form some idea of the appearance of our north polar basin. This angular position of the Moon is analogous to that of the earth, consequently the Moon's Seasons during her revolution round the earth must be the same as ours during the year.

It may here be stated that polarity alone is sufficient to flatten the poles of an elastic globe, and to increase the intensity of the forces from its equator towards the extremity of the axis. Indeed, according to observations and experiments made during the growth of spheroidal tropical fruits, a similar polar action has been detected; the stem forms the north, and the opposite point the south pole, from whence the gases evolve with a circular action back again to the stem. See also the orange and the apple. Rotation is not necessary to produce a spheroidal figure, as may be observed on reference to the Moon, which does not rotate on an axis, but simply revolves round the earth as if she were a portion of a ring; nor can the combination of centripetal and centrifugal forces produce the variation we find in terrestrial attraction by the pendulums, &c., from the poles to the equator. Theory and observation have never agreed on these points. According to barometrical observations, we find the height

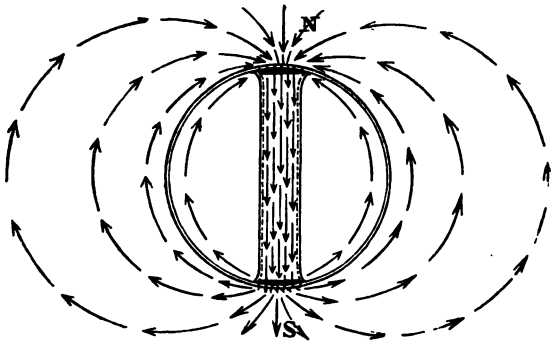
* For a more perfect representation of S, see Frontispiece.

or pressure of the atmosphere about $\frac{1}{30}$th less in the polar regions, but of greater density than at the equator.

The terrestrial magnetic force alone accounts for the whole phænomena strictly as observed.

We find by experiments that a magnetic force cannot exist without a *continued action*; consequently the magnetic needles, like the wind vanes, are merely the indicators of the polar stream, and that this stream is constantly moving from the south pole to the north, and, according to experiment and analogy, completing the circle of activity through the medium of the axis. This fact is proved daily by the action of the magnetic telegraphs.

Fig. 19.



In making experiments with solutions of various minerals, under the influence of magnetic currents, from pole to pole, we find that although the circuit of activity is completed and kept up by means of the magnetic axis, yet the substances never pass through.

It is only the hydrogen,—the active spirit as it were, that passes through the axis, or the wires out from the south pole and in again at the north pole.

The various terrestrial substances which this subtile power

controls and modifies on the surface of the globe for the uses of the organic kingdoms, are dissolved and left behind in the ocean at the north polar basin to be reproduced again from the ocean at the south pole. Thus the action is perpetuated; the changes of the surface with the very same elements are continued, and this effect can be proved and imitated by means of a magnetic battery, with solutions in the decomposing trough.

The minerals and the waters may thus remain for ever fulfilling their offices without causing any disorganization

Fig. 20.

in their general character, as liquid compounds or crystals; but such is not the case with the organic kingdoms. The latter must retrograde continually southward to suitable climes, and be provided with a sufficient area of dry land in each zone to be preserved, otherwise they would all become by degrees extinct, which has been the case with many species and genera since the Creation.

With regard to a magnetic globe, we find also by expe-

riment that its attraction is the same whether the globe be solid or hollow, provided the area of the section of the axis be equal. Therefore no idea of the nature of the interior can be formed by experimenting on the external attraction. This important fact is not sufficiently attended to by mathematicians engaged in attempting to ascertain the density of the earth.

The great changes, in and on the surface of the earth, (however slow and imperceptible may be the subterranean force that produces them), must constantly alter the relative positions of terrestrial points as compared with the heavenly bodies. We have found by astronomical observations that such changes are going on, and that they destroy, in the lapse of a moderate number of years, the arrangement of the catalogues of stars, and make it necessary to reconstruct them. Since the formation of the earliest catalogues on record, the place of the equinox has retrograded about 30 degrees. This change is called the "Precession of the Equinoxes," which was only discovered about 110 years ago, when the surface of the earth was considered as fixed and immoveable; and consequently to account for the apparent alterations then detected, astronomers were obliged to assume a bodily movement, *i. e.* of the whole globe. No movement in the *geographical position of places* could be entertained, nor has it been suspected until it was announced by the author some years ago, and partially proved by astronomical observations in South America. The idea of the earth moving, elevating and depressing, appear in open and striking contradiction to the evidences of the senses, and in opposition to the ideas of common observers, but not more so than those of Astronomy. The latter science has demonstrated that the earth on which we stand, and which

has served for ages as the unshaken foundation of the firmest structures, either of art or nature, whirls on its axis daily, and revolves round the sun annually. Geological science now demonstrates that the very surface of the globe has *an undulating and polar movement*; and thus the earth, the seat of man and his works, is completely divested of all its attributes of fixity. These must necessarily appear startling announcements to those who have not studied the natural operations of the world; nevertheless they are not less true, and are capable of being tested and proved as substantial facts, although they may be received as reluctantly by the world as the daily rotation of the Earth was received at the time of Galileo, and will perhaps be opposed for many years; but such is the fate of all systems that happen to be contrary to our preconceived notions, which nothing but time, experience, and the removal of prejudices and untenable doctrines can correct. The daily rotation of our globe was not known until it was announced by Galileo, and many plausible arguments were brought forward by astronomers and mathematicians to prove the impossibility of such a rotation. It was a long time before such an idea could be reconciled, as it appeared contrary to the evidence of the senses; besides, the very fact of the terrestrial pole always corresponding to the same stars was held as a sufficient argument against the revolution of the globe round the sun; ultimately the rotation was accepted, and it enabled astronomers to understand better the movements of the planets than they did before that period, although they made no difference in the astronomical calculations.

In entering into this question, it would be well to acquaint those who have not studied ancient geography, as-

tronomy and physical science, that the configuration of the land, as now represented on our globe, is of a very recent date, and does not, by any means, agree with Ptolemy's observations or the ancient maps of the world. Indeed, we find the changes so rapid in the Southern Hemisphere as to render it necessary to make frequent periodical surveys and new charts. Even so recently as the commencement of the last century, the position of some of the European *Observatories* could not be depended upon within twenty minutes. What then must be the errors of places less favoured by proper surveys, and permanent advantages for scientific observations! When Bradley first discovered the variation in the apparent position of the fixed stars, he attributed it to motion in the imaginary pole of the heavens itself.

Further observations led him to abandon this theory, inasmuch as direct observations did not confirm it, and it was subsequently referred to a slow conical oscillation of the earth bodily, which theory, for the want of a better, and in the absence of any knowledge of the superficial changes above alluded to, is entertained to this day by astronomers, although incorrect in its application.

This phænomenon is called the "Precession of the Equinoxes," owing to the imaginary points of the intersection of the Equator and Ecliptic continually varying at the rate of 50″ per annum, thus changing the relative position of the fixed stars. Movements of this description, be they terrestrial or celestial, produce similar relative changes, and may be made to conform to any theory, if the calculations be founded on the *geometry of the paths of the heavenly bodies*, which are the true elements of Astronomy, and not Physics.

The ancient astronomers, with their theory of a fixed

globe and the revolution of a celestial vault, calculated the period of the eclipses, &c. as we do now, without the aid of modern theories and refined instruments. This shows how little our *physical* theory of the heavenly bodies has to do with the question, and how much we have been misled in various scientific questions by the mistaken infallibility of mathematical theories, and by substituting the laws of geometry for those of physics. The physico-geometrical laws have encouraged the search for perpetual motion, and have led many of the greatest deductive mathematical philosophers to become atheists, from the false assumption that motion required no constant active principle, nor the aid of the Prime Mover of all things to govern the order and circular arrangements of the Universe.

Our Nautical Almanack entirely depends on the correctness of constant observations and calculations founded on uniform movements and on the geometry of the paths of the heavenly bodies, and not on any physical theory of the system.

So also with our tides, and numerous other terrestrial phænomena which could be mentioned: they depend on classified facts and periodical observations.

Therefore we must not imagine that our astronomical physical theories are infallible, or that they are beyond correction in their *physical* deductions. Had Kepler been acquainted with the laws of terrestrial refraction,—had he known that the variable diameter of the sun was an optical illusion arising from its variable angular position in the atmospheric lens, and not that its distances from the earth varied,—he would not have made the annual orbit into an ellipse: or had astronomers existed at the same time at the Antipodes, they would have corrected the error by stating

that the variable diameters of the sun to them was quite the reverse to that observed in Europe, and that the sun appeared large to them in June and small in December. Yet this notion is still encouraged by our astronomers; but fortunately as the mean diameter of the sun is generally employed, and that nearly agrees with the observed diameter at the angle usually taken to determine the longitude, it does not lead to very material errors*.

To return to the question at issue respecting terrestrial changes, it may be stated that a gradual spiral movement of the earth's surface towards the North polar axis, at the rate observed, will strictly account for the phænomenon of the Precession, and in a much more satisfactory manner than the present theory of a bodily oscillation of the globe. Indeed Bradley was never satisfied with this theory, inasmuch as the observations did not agree with such a movement; but for the want of a better, with the usual aid of corrections for nutation, aberration, refraction, &c., it has been, like the theory of the tides, preserved amongst our scientific records more as a memorial than for scientific utility. The

* In latitude 40° south, on the 2nd of June, 1852, I drew the attention of Capt. Smith, of the Futtel Oheb, to this subject, and requested him to make direct observations to prove the correctness of my observations and tables of diameters and refraction. The Nautical Almanack indicated a diameter of 31′ 34″. The meridian altitude of the sun was 22°, and its actual apparent diameter was found to be 32′ 22″, being a difference of 48″, thus causing an error of several miles in taking the longitude. The captain became so convinced, that he determined in future to be guided by the variable diameter of the sun according to its angular position; and I would recommend all others to do the same in taking astronomical observations in the Southern Hemisphere. Astronomers freely acknowledge that the laws of atmospherical refraction are still very unsatisfactory. The cause of this uncertainty affects some of the most important *data* of astronomy, and needs but direct observations to be corrected and established like the laws of optics.

comparatively short period which has elapsed since the above change was first detected (about 110 years ago), the exceedingly slow rate at which the changes take place, with the strong bias for the preconceived geometrical theory, with all its imperfections, rather than accepting any new principle, all have precluded the possibility of determining, with any degree of accuracy, the actual amount of the movement along the meridian; but it is to be hoped that this very important question will no longer be neglected. However, it is sufficient for our present object to state that the movement of the surface towards the north pole, since the change has been discovered and compared with the ancient catalogues of the stars, has been at the rate in round numbers of about 20 seconds per annum—1 minute in 3 years—or say 1 degree in 180 years; the rate of movement may be a trifle less, but cannot be more. Near the pole the variations in the position of the stars are very considerable: the tables only serve for a few years; hence nearly all astronomical computations are obliged to be reduced and measured from the centre of the earth; thus astronomical errors arising from the instability of the surface are avoided.

Supposing this movement of the earth's surface from the south to the north to be constant, it follows, that at the above rate of progression, the spot on which London now stands must have been in the equator about 9180 years ago; and that the whole of England will be within the Arctic circle in about 2800 years hence.

According to the ancient records of the Egyptian priests, the sun was to the north of Egypt since the commencement of the dynasty of their kings; also some of the stars, which are now south of that country: and at a still more

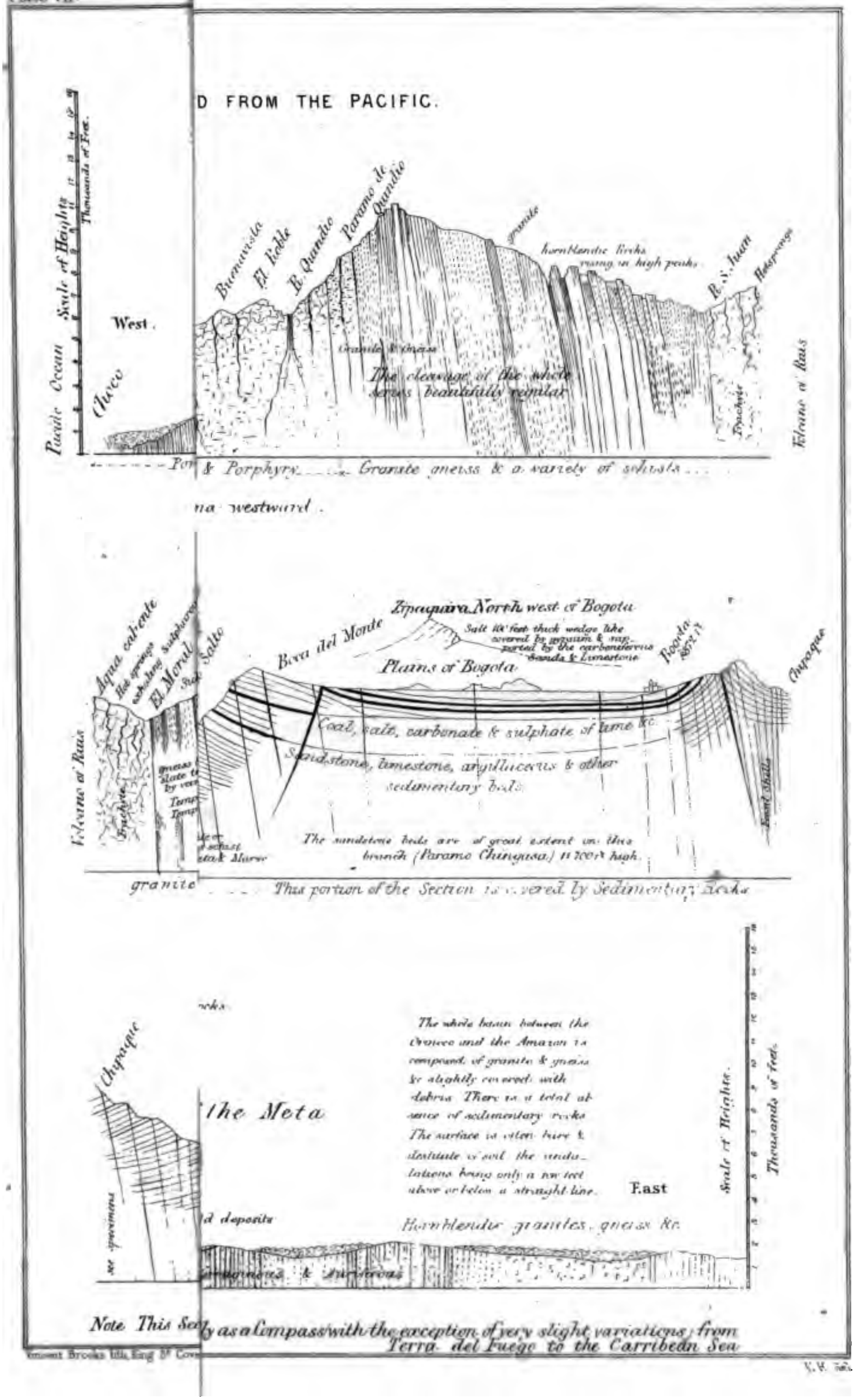
recent period, the sun was seen in the zenith of a certain well which is now situated very far to the north. Although the observations of the ancient philosophers have been lost in the lapse of ages, the records of the past history of the earth have been laid down and preserved by a power beyond the reach of human control and imperfections; hence Geology may recall the past and anticipate the future by means of direct observations and its organic remains.

To conclude, the great undulating movement of the crystalline film, its various deposits and saline covering, governed by the constant presence of that power called polarity or magnetism,—moves from pole to pole, carrying everything with it. This power renovates the surface of the earth to suit the wants of successive generations of animated nature in all ages. Our globe is not the result of chance, or of any imaginary compound of wrecks and confused chaos thrown into space by the rotation of an incandescent sun, then moulded and sustained by centripetal and centrifugal forces, cracked and patched by melted matter; on the contrary, it has been formed, and is still controlled, by a sublime law of action little noticed by man;—it has a beginning and an ending, like all the productions of the organic kingdom.

The south polar basin is the starting-point of the embryo of our terrestrial habitation:—the Southern Hemisphere is the Spring; the Equator is its Summer; the Northern Hemisphere its Autumn, and the North polar basin its final dissolution. Hence the study of the physical operations of nature, *i. e.* the science of Geology and Magnetism, cannot be surpassed in the magnitude of its utility, or in the sublimity of its objects. Not only is it alone second to astronomy in its scientific grandeur and deduction,—it is

the stepping-stone and threshold to the temple of the *physical* sciences, and enables us to unfold some of the mysteries of the works of the Creation. The science of Geology, in combination with the surrounding controlling power which we have briefly noticed, forcibly impresses us with the fact that the human race is placed here only for a season. The world and all its productions imperceptibly pass away unobserved by the millions of animated beings who have their existence on it; we are, as it were, like parasitical insects, placed on a film which is perpetually changing, has its beginning and ending, and is equally subject to decay as ourselves. The minerals and the rocks, the rivers and the seas, the islands and the continents, with their vegetable and animal covering, are perpetually changing, leaving but faint traces of their relics behind. There is no standing still, and no resting place in the annals of the world. Generation after generation, like the shadow on the dial, pass away, and all are continually merging into eternity, according to the will and sublime laws of our Maker.

Plate VII



Vincent Brooks lith. Eng. St. Cov.

V. H. del.